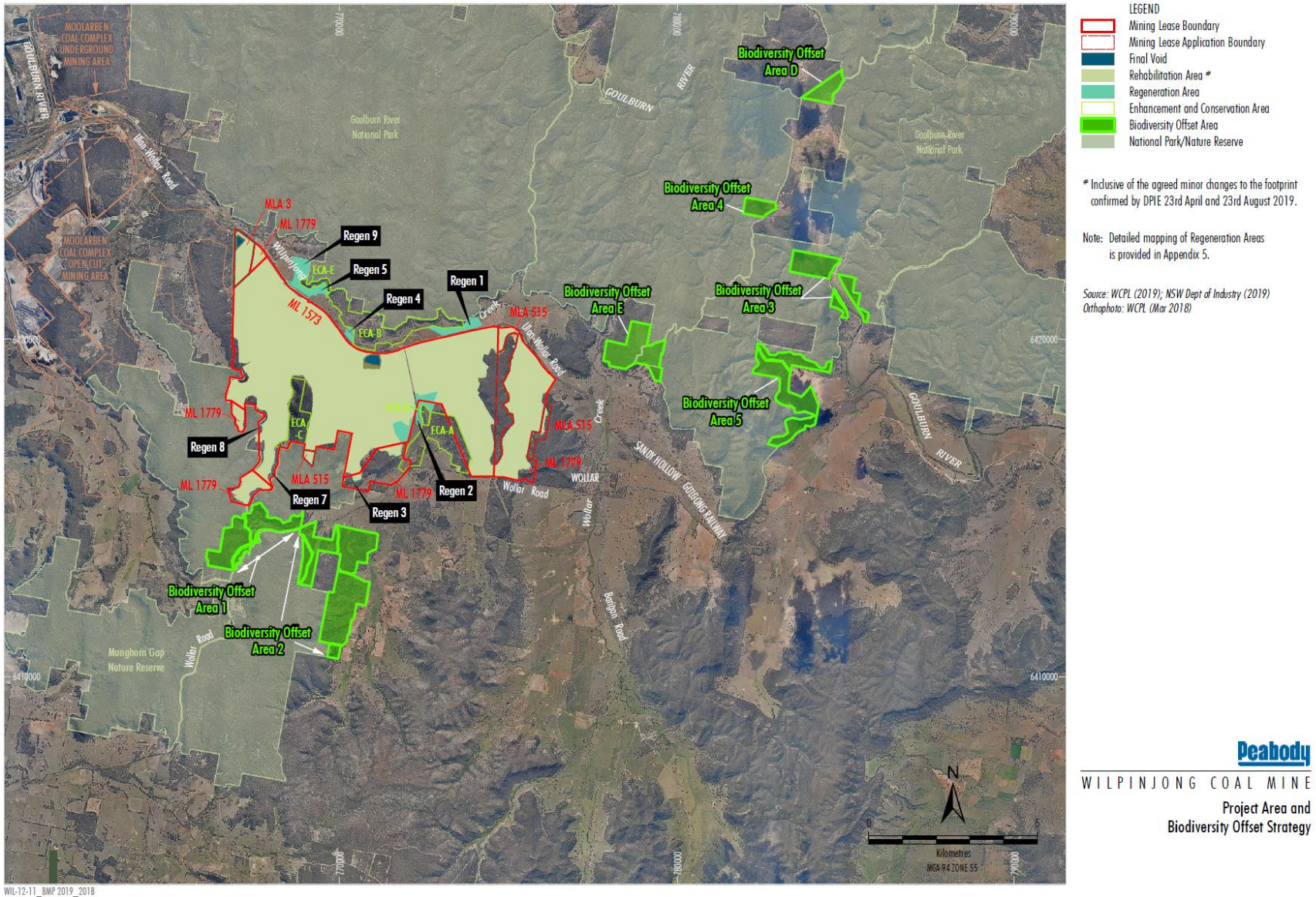
APPENDIX 5 – BIODIVERSITY

Biodiversity Offset Strategy



LEGEND

- Mining Lease Boundary
- Mining Lease Application Boundary
- Final Void
- Rehabilitation Area #
- Regeneration Area
- Enhancement and Conservation Area
- Biodiversity Offset Area
- National Park/Nature Reserve

Inclusive of the agreed minor changes to the footprint confirmed by DPIE 23rd April and 23rd August 2019.

Note: Detailed mapping of Regeneration Areas is provided in Appendix 5.

Source: WCPL (2019); NSW Dept of Industry (2019)
Orthophoto: WCPL (Mar 2018)

Peabody

WILPINJONG COAL MINE

Project Area and
Biodiversity Offset Strategy

Biodiversity Reports

2019 Annual Biodiversity Monitoring Report

Wilpinjong Coal Pty Ltd

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DOCUMENT TRACKING

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Template 2.8.1

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Abbreviations

Abbreviation	Description
BC Act	*Biodiversity Conservation Act 2016*
BMP	Biodiversity Management Plan
BOA	Biodiversity Offset Area
BVT	Biometric Vegetation Type
DNG	Derived native grassland
EC	Exotic Cover
ECA	Enhancement and Conservation Area
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
ELA	Eco Logical Australia Pty Ltd
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FL	Fallen Logs
IPT	Interim Performance Target
LFA	Landscape Function Analysis
LOI	Landscape Organisation Index
Microbat	Microchiroptera bat
ML	Mining Lease
MOP	Mine Operations Plan
NGC	Native Ground Cover
NGCG	Native Ground Cover Grass
NGCO	Native Ground Cover Other
NGCS	Native Ground Cover Shrub
NMC	Native Midstorey Cover
NOC	Native Overstorey Cover
NP	National Park
NPWS	National Parks and Wildlife Service
NSR	Native Species Richness
NTH	Number of Trees with Hollows
OR	Overstorey Regeneration
OEH	Office of Environment and Heritage
PA	Project Approval
SSA	Soil Surface Assessment
SVS	Site Value Score

Abbreviation	Description
TARP	Trigger Action Response Plan
WCM	Wilpinjong Coal Mine
WCPL	Wilpinjong Coal Pty Ltd
WEP	Wilpinjong Extension Project
WSDSF	Western Slopes Dry Sclerophyll Forest
WSGW	Western Slopes Grassy Woodland

Summary of key findings

Biodiversity monitoring was undertaken at the Wilpinjong Coal Mine (WCM) during 2019, representing the fourth year of monitoring for Autumn, and the fifth year of monitoring for Spring under the methodology prescribed in the WCM Biodiversity Management Plan (BMP) (WCPL 2017). Monitoring was undertaken at established monitoring sites across the WCM Management Domains, including Biodiversity Offset Areas, Enhancement and Conservation Areas, Regeneration and Rehabilitation areas. A series of Reference sites were monitored to provide comparative results.

Monitoring results have been analysed and compared against Performance and Completion Criteria prescribed by the BMP (WCPL 2017) to measure the progress of the Management Domains (excluding Rehabilitation Areas) towards biodiversity targets. Updated Interim Performance and Completion Criteria specific to Rehabilitation Area BioMetric Vegetation Types (BVTs) were approved in April 2019 and have been analysed and compared against Rehabilitation Area floristic monitoring results. Newly established local Reference sites will be used to further update the Rehabilitation BVT Performance and Completion Criteria, along with the broader floristic monitoring program, with these updates to be detailed in the revised BMP (WCPL 2019).

Vegetation monitoring was undertaken within all Management Domains and Reference sites during 2019. Five Western Slopes Dry Sclerophyll Forest sites and six Western Slopes Grassy Woodland sites achieved the Interim Performance Target (IPT) for their overall Site Value Scores (SVS), however, most SVS declined in comparison to the 2018 results, potentially attributable to below average rainfall during 2019. Drought conditions have been experienced across the Central Tablelands region since 2017, with 2019 recording 382.3 mm less rain than the historical average. No sites achieved the ITP for all site attribute scores. Most sites achieved the attribute targets for Native Overstorey Cover, Exotic Cover and Number of Trees with Hollows.

Monitoring results from Reference sites during both Autumn and Spring 2018 continue to add to the dataset to be used for comparison against vegetation monitoring results within the Management Domains. Ongoing monitoring data collected at the Reference sites in 2019 will be used to develop more relevant, locally based benchmark values against which future monitoring data would be analysed. Additional Reference sites specific to rehabilitation BVTs were established in 2019 and a review is currently underway to determine their suitability as locally based benchmarks.

Landscape Organisation Index scores, developed through analysis of the data collected from Landscape Function Analysis monitoring, were high across all monitoring sites, although most sites had decreased marginally compared to 2018 results. Similarly, low levels of erosion observed throughout previous monitoring seasons can be correlated with the high Soil Surface Assessment stability scores and the absence of any substantial erosion recorded since 2015. This is consistent with 2019 results, with only two sites not yet reaching the stability completion criteria. Overall these combined data sets demonstrate that consistently stable landforms occur across the WCM Management Domains.

Fauna monitoring undertaken in 2019 recorded 141 fauna species, including 118 birds, one amphibian, 12 reptiles and ten mammals (including ten positively identified microbat species). Fourteen species (11 bird species and three positively identified microbat species) listed as threatened under the NSW

Biodiversity Conservation Act 2016 and/or the Commonwealth *Environmental Protection and Biodiversity Act 1999* were recorded.

Long term analysis of consistent monitoring data is required to determine if the results are attributed to management practices, seasonal variation or are indicative of a long-term trend across the landscape.

1. Introduction

Wilpinjong Coal Pty Ltd (WCPL), a wholly owned subsidiary of Peabody Energy Australia Pty Ltd (Peabody), operates the Wilpinjong Coal Mine (WCM) located in the western coalfields of NSW approximately 48 km north-east of Mudgee, within the Mid-Western Regional Council (MWRC) Local Government Area (LGA).

The WCM originally operated under Project Approval (PA) 05-0021, granted under Part 3A of the NSW *Environmental Planning and Assessment Act 1979* on 1 February 2006. A series of modifications to PA 05-0021 were approved until it was superseded by Development Consent SSD-6764, granted on 24 April 2017 for the Wilpinjong Extension Project (WEP).

A Biodiversity Offset Strategy was developed and augmented by WCPL to address impacts on threatened species, populations or communities listed under the NSW *Biodiversity Conservation Act 2016* (BC Act) and /or Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act). The strategy comprises a package of Management Domains which includes Biodiversity Offset Areas (BOAs) that will be set aside for conservation and managed in perpetuity, and a number of Enhancement and Conservation Areas (ECAs), regeneration and rehabilitation areas. The total area of all the Management Domains is in excess of 4,700 ha.

- **Biodiversity Offset Areas (BOAs)**: The BOAs comprise significant areas of largely undisturbed remnant vegetation (1,101.97 ha) and require minimal management to maintain ecological integrity. The BOAs are located next to the Goulburn River National Park and Munghorn Gap Nature Reserve with the aim that these parcels of land will all be transferred to the National Parks Estate. All land within BOAs D and E were transferred to the National Parks Estate after the winter monitoring 2019 and are now under the management of the NSW National Parks and Wildlife Service (NPWS). Further biodiversity monitoring within BOAs D and E is no longer required. Five BOAs (1-5) were added to the monitoring program in winter 2018. BOAs 1-5 will also be transferred into the National Parks Estate at a later date in accordance with Schedule 3, Conditions 32 and 35 of Development Consent SSD-6764.
- **Enhancement and Conservation Areas (ECAs)**: In 2012 WCPL entered into a Conservation Agreement with the NSW Minister for the Environment for three parcels of land (480 ha) surrounding ML 1573 – ECAs A, B and C. These areas have been established for conservation purposes and enhanced though weed management, revegetation, selective grazing.
- **Regeneration and Rehabilitation Areas**: Regeneration and rehabilitation areas (3,200 ha) have been established on areas of WCPL owned land next to the ML as part of the WCP Environmental Impact Statement (EIS) (WCPL 2005). These areas were predominately cleared agricultural land and will be rehabilitated to woodland enhancing wildlife connectivity.

A Biodiversity Management Plan (BMP) was developed and an annual monitoring program was implemented across all Management Domains using both the Biometric methodology (Gibbons et al 2009) and Landscape Function Analysis (LFA; Tongway and Hindley 2004) for assessing ecosystem function, habitat complexity and rehabilitation progress and success. Measurable quantitative Completion Criteria and Interim Performance Targets (IPT) were established to ensure the areas are

managed and progressing towards the overall completion objectives (WCPL 2017). Twenty-two (22) reference sites were also established within the Goulburn River National Park and Turill State Conservation Area in areas of equivalent habitat types adjacent to Management Domains to provide comparative data so that the long-term progress of the Management Domains can be determined. Following approval of the WEP, all reference sites were reassessed to determine if they meet the required Biometric Vegetation Type (BVT) determined by the offset strategy requirements. Only reference sites that meet the requirements were surveyed in Spring 2019. New reference sites within the required BVTs were surveyed and established in 2019, to be included in the monitoring program from Spring 2020 onwards.

Eco Logical Australia (ELA) was engaged by WCPL to undertake biodiversity monitoring consistent with the requirements and methods outlined in the BMP (WCPL 2017). Monitoring consisted of vegetation monitoring at established biometric monitoring plots in Autumn and Spring, LFA monitoring in Spring, bird monitoring across three seasons (Summer, Winter and Spring), and ground fauna (amphibians, mammals and reptiles) monitoring in Spring. Microbat monitoring using Anabat detectors was also undertaken during Spring.

1.1 Objective

The objective of the biodiversity monitoring at WCPL is to measure the progress of the Management Domains towards the relevant Completion Criteria prescribed in the BMP (WCPL 2017). The Management Domains are listed and shown in Table 1 and Figure 1. Monitoring results from Spring 2015 and Autumn 2016 represent the baseline (Year 0) data for each monitoring site, with the 2019 results presented in this report representing Year 4 and Year 3 data for Spring and Autumn respectively.

Table 1: WCPL Management Domains

Management Domain	Area (ha)	Location Description
BOA-D*	50.36	Located approximately 12 km north-east of Mining Lease (ML) 1573.
BOA-E*	160.18	Located approximately 3 km east of ML 1573
BOA-1	201.12	Located to the south-west of ML 1573
BOA-2	157.73	Located to the south of the ML 1573
BOA-3	128.45	Located to the north-west of ML 1573, access via the Wollara Downs property
BOA-4	39.02	Located to the north-west of ML 1573, access via Mogo Road
BOA-5	221.24	Located to the west of ML 1573, access via the Wollara Downs property
ECA-A	189.56	Located to the south-east of ML 1573
ECA-B	233.59	Located to the north of ML 1573
ECA-C	96.23	Located in the south-east portion of ML 1573
Regeneration Area 1	27.61	Located adjacent to the eastern boundary of the approved disturbance area
Regeneration Area 2	14.00	Located on the western side of ECA-A

Management Domain	Area (ha)	Location Description
Regeneration Areas 3, 7 and 8	1.28	Located adjacent to the south and south western boundary of the approved disturbance area
Regeneration Area 4	6.53	Located on the north side of the mine, between the approved disturbance boundary and ECA-B
Regeneration Area 5	23.66	Located towards the western end of ECA-B
Regeneration Area 9	27.57	Located towards the western end of ECA-B
Rehabilitation Areas	Variable	Includes areas within the approved disturbance area for the mine, including active and future mining areas, infrastructure areas and rehabilitation of disturbed areas that is undertaken on a progressive basis in accordance with the approved WCPL Mine Operations Plan (MOP) (WCPL 2019)

Note: Regeneration Area 6 has been removed with the approval of the Wilpinjong Extension Project.

*Part of national park estate and no further monitoring is required

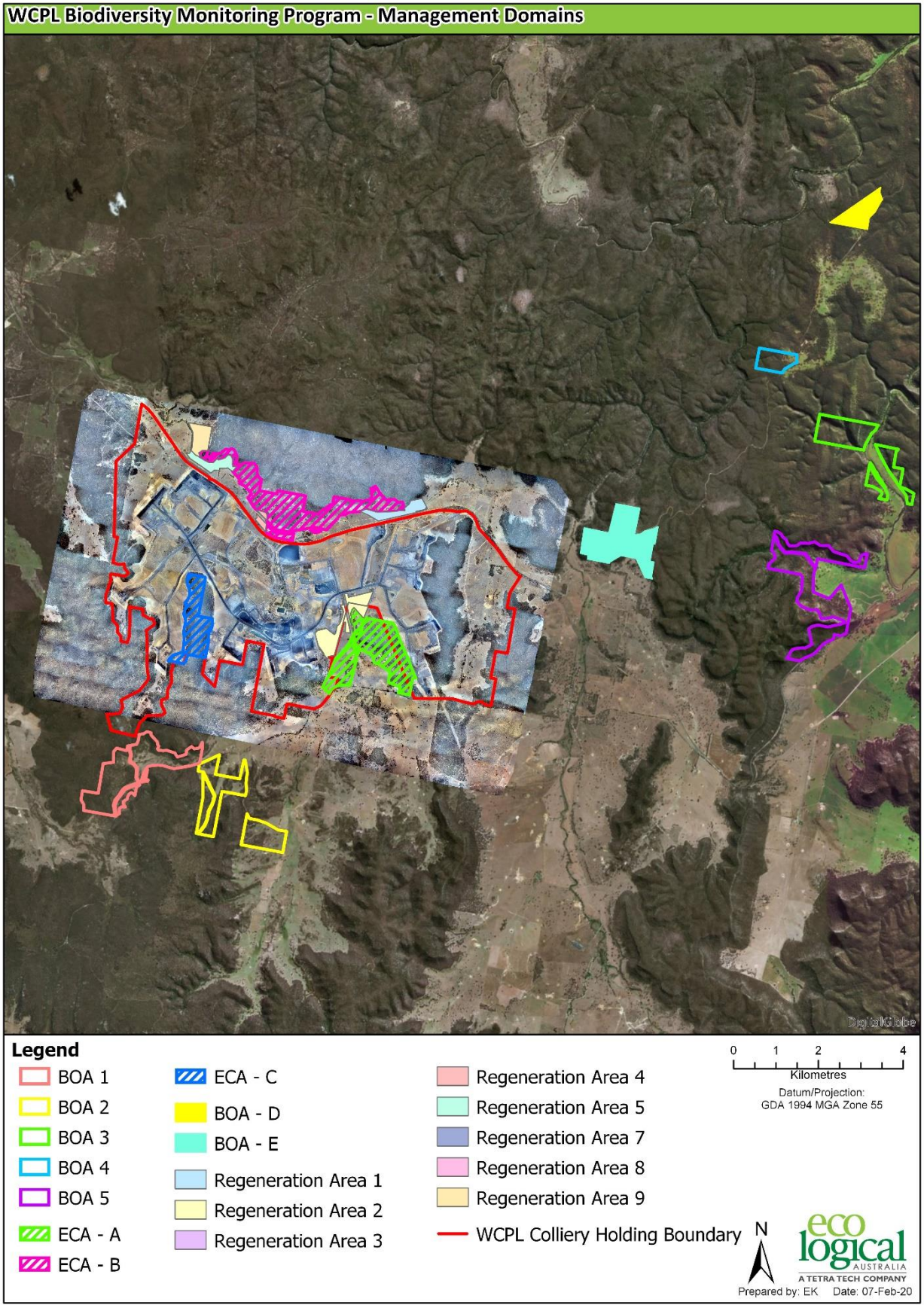

Figure 1: WCPL Management Domains

1.2 Previous monitoring

Biodiversity assessment and monitoring of the Management Domains was undertaken as part of the baseline studies and vegetation community mapping components of the original WCM Environmental Impact Assessment (EIA), as well as for the rehabilitation areas and ECAs under the rehabilitation monitoring requirements of the Mining Operations Plan (MOP) and previous versions of the Biodiversity Management Plan. However, this data does not directly correlate with the performance & completion criteria contained in the current BMP (WCPL 2017), and therefore is unable to be used to measure the effectiveness of management practices to improve biodiversity values within the Management Domains.

A number of sites have been discontinued from annual monitoring either due to the approved WEP, having been transferred to the National Parks Estate in accordance with Schedule 3, Conditions 32 and 35 of Development Consent SSD-6764 or were no longer deemed suitable. A list of discontinued sites is shown in **Appendix A**.

The monitoring program outlined in the BMP (WCPL 2017) commenced in Spring 2015. Monitoring undertaken during 2019 was consistent with the methods and approach described in the 2015, 2016, 2017 and 2018 annual monitoring reports (ELA 2016, ELA 2017, ELA 2018 and ELA 2019) and the BMP (WCPL 2017).

1.3 Assessment against Rehabilitation BVT Benchmarks and WCPL Performance Criteria

Interim Performance and Completion Criteria for Rehabilitation areas have been upgraded. These performance and completion criteria were approved by DPIE on 23 April 2019 and will be incorporated into the updated BMP (WCPL 2019), which is currently pending approval by NSW Department of Planning, Industry and Environment (DPIE). Within this monitoring report, these performance criteria, along with benchmark attributes (OEH 2017), were compared with the Rehabilitation Areas 2019 monitoring data. These Interim Performance and Completion Criteria will be further updated based upon data collected from newly established local Reference Sites for each specific rehabilitation BVT.

The reference monitoring sites that do not fit the required rehabilitation BVTs will cease to be monitored and will not be used for comparisons. LFA sites will still remain constant and will trigger the TARPs outlined in the BMP. Post approval of the updated BMP (WCPL 2019), BOAs and ECAs will continue to be monitored, however, will not be comparable to the Performance and Completion Criteria as these are specific to Rehabilitation Areas. BOAs and ECAs will instead be compared and monitored for resilience, and management actions will be implemented where resilience is Poor and/or not progressing to High.

1.4 Assessment against Interim Performance Targets

The BMP (WCPL 2017) outlines Interim Performance Targets (IPTs) that will be used to determine progression towards the Completion Criteria and overall mine closure and offset objectives. These IPTs apply to the BOAs, ECAs and Regeneration Areas (see **Section 1.3** above for assessment of Rehabilitation Areas). These IPTs will be superseded once the new BVT reference sites are established and accepted by DPIE, and the revised BMP (WCPL 2019) is approved. The IPTs provide targets against which the progression of management activities can be compared to over time. The Completion Criteria will be

used to assess the success of management activities against the proposed final land use in accordance with Schedule 3, Condition 37 of the Development Consent.

1.4.1 Vegetation

The BMP (WCPL 2017), (see **Tables 15-19**; WCPL 2017) defines IPTs and benchmark values (Completion Criteria) for low, moderate to good and high condition vegetation within each of the Keith Vegetation Classes (Western Slopes Dry Sclerophyll Forest (WSDSF) and Western Slopes Grassy Woodland (WSGW). Benchmark conditions represents the ultimate management target for native vegetation across the Mine however, given the 20 year management timeframe may be considered unrealistic therefore a passive movement towards benchmark condition is considered a more suitable and feasible context for establishing performance targets.

1.4.2 Landscape Function Analysis (LFA)

LFA is a rapid technique to monitor landscape rehabilitation (Tongway and Hindley 2004). The BMP (WCPL 2017) defines Completion Criteria for a self-sustaining landform as achievement of a score of 50 or more for each Soil Surface Assessment (SSA) Index. The BMP (WCPL 2017) further states that incremental improvement (an increase of five or more index points annually) is anticipated, with achievement of Completion Criteria by Year 10.

2. Methodology

The 2019 biodiversity monitoring program was undertaken in accordance with the methods and survey techniques prescribed in the BMP (WCPL 2017). The biodiversity monitoring program comprised the following components:

- Vegetation monitoring
- Landscape stability monitoring using LFA
- Terrestrial fauna monitoring

Weather conditions during the Autumn, Winter and Spring 2019 monitoring are presented in **Appendix B**. Additional information on all vegetation, LFA and fauna monitoring sites can be found in **Appendix C**.

2.1 Vegetation monitoring (Biometric)

Autumn vegetation monitoring was undertaken between 12 March and 18 March 2019 by ELA ecologists Elise Keane, Tomas Kelly, Kate Maslen and Angelina Siegrist. Autumn vegetation monitoring included 16 floristic monitoring sites and four reference sites located within NPWS managed estates. Spring vegetation monitoring was undertaken between 16 September and 6 November 2019 by ELA ecologists Elise Keane, Tomas Kelly, Kate Maslen and Stacey Wilson. Spring vegetation monitoring included 13 floristic monitoring sites, and one reference site located within NPWS managed estate. The locations of vegetation monitoring sites are illustrated below in **Figure 2** to **Figure 5**.

Vegetation monitoring was undertaken utilising the method of plot assessment prescribed in the BMP (WCPL 2017). Permanent Biometric plots, comprising a 20 m x 20 m (0.04 ha) plot nested within a 20 m x 50 m plot, were established in Spring 2015, Autumn 2016 and Spring 2018 and were monitored in accordance with the methods described in Section 9.1 of the BMP (WCPL 2017). Within each plot, the following data was collected:

- native species richness (NSR), cover and abundance within the 20 m x 20 m plot
- native overstorey cover (NOC) and native mid-storey cover (NMS) – at regular 5 m intervals along 50 m transect (10 points),
- native ground stratum (grass, shrub, other) and exotic cover (EC) – at regular 1 m intervals along 50 m transect (50 points)
- habitat features (number of trees with hollows (NTH), length of fallen logs (FL)) and proportion of overstorey species regeneration – within 20 m x 50 m plot.

All vascular plants species were recorded and identified to the lowest taxonomic level possible, with samples of unknown species collected for further identification.

A Site Value Score (SVS) was calculated for each site using the BioMetric Tool (NSW Department Environment Climate Change and Water, DECCW 2011) which combines the quality and quantity of native vegetation by measuring ten condition variables within a plot compared to the pre-European benchmarks for the Vegetation Class.

2.2 Landscape Function Analysis

LFA monitoring was undertaken between 17 September to 6 November 2019 by ELA ecologists Elise Keane, Tomas Kelly, Kate Maslen and Stacey Wilson. LFA monitoring was undertaken in accordance with the methods prescribed in Tongway and Hindley (2004) and the BMP (WCPL 2017).

LFA assessments were undertaken at 11 monitoring sites, including nine within WCPL Management Domains and two references sites located within NPWS managed estate (Figure 4 and Figure 5).

At each LFA site, a 50 m transect line was established downslope between transect start and end markers. The majority of LFA transects directly correspond to the 50 m Biometric transect of the respective monitoring site. However, at several sites, the LFA transect does not align with the Biometric transect, predominantly due to the Biometric transect being established across slope rather than downslope in these locations. Along each LFA transect, LFA attributes were assessed to monitor the Landscape Organisation Index (LOI) and SSA.

2.2.1 Landscape organisation index

The LOI characterises and maps the spatial patterns of resource loss or accumulation at a site. The LOI provides a proportion of the transect occupied by patches (patches being landscape elements that are relatively permanent and provide stable, resource accumulating structures, such as grassy tussocks, ground cover and logs). A higher LOI implies a more stable transect that is less prone to erosion, with a LOI of 1.00 indicating that an entire transect is occupied by patches. The SSA is more in depth, providing an index (0-100) of Stability, Soil Infiltration and Nutrient Cycling for the whole of landscape (transect). Table 20 in the BMP (WCPL 2017) summarises the SSA attributes that contribute to each of these indices (see Table 2 below).

According to the LFA method, patches are long-lived/term features that obstruct or divert water flow and/or collect/filer out material from runoff and where there is evidence of resource accumulation. Inter-patches are zones where resources such as water, soil materials and litter may be mobilised and freely transported either down slope when water is the active agent or down-wind when aeolian processes are active.

The following data was recorded for each patch/inter-patch along each transect:

- Distance (m) from the start of the transect
- Patch width (cm)
- Patch/inter-patch identification

The following patch types were defined and monitored across all monitoring sites and monitoring periods:

- Bare soil
- Litter (including annual plants)
- Rock (<5 cm diameter)
- Log (>10 cm diameter)
- Ground cover (perennial)
- Shrub/tree

- Cryptogam
- Any combinations of the above (e.g. ground cover – litter patch).

2.2.2 Soil surface assessment (SSA)

Each patch/inter-patch type identified in the landscape organisation data log was subject to a SSA. A subset of up to five occurrences of each patch/inter-patch type were monitored, and data relating to eleven; Soil Surface Condition Indicators (SSCIs) were collected along the 50 m transect (Table 2).

Table 2: Soil Surface Condition Indicators used to determine the overall Soil Surface Analysis (see Table 20 BMP: WCPL 2017)

SSCI	Description
Rain splash protection	Percentage cover of perennial vegetation to a height of 0.5 m. plus rocks > 2 cm and woody material > 1 cm in diameter or other long-lived, immoveable objects.
Perennial vegetation cover	Percentage perennial vegetation cover.
Litter	Percentage cover of annual grasses and ephemeral herbage (both standing and detached) as well as detached leaves, stems, twigs, fruit, dung, etc.
Cryptogam cover	Percentage cover of algae, fungi, lichens, mosses, liverworts and fruiting bodies of mycorrhizas.
Crust brokenness	Categorises soil crusts from 0-4 where 0 refers to 'no crust present' and 4 refers to an 'intact and smooth' soil crust.
Soil erosion type and severity	Categorises the aerial extent and severity of various erosion types from 'Insignificant' to 'Severe'.
Deposited materials	Categorises the extent and depth of deposited alluvial material
Soil surface roughness	Categorises the depth of surface depressions from 'smooth' to 'deep' depressions.
Surface nature (resistance to disturbance)	Categorises the soils capacity to resist disturbance based on the soils 'hardness' or 'brittleness'.
Slake Test	Categorises the soils stability when exposed to water
Texture	Categorises the soils water infiltration capacity from 'very slow' to 'high'

Baseline data for the Slake Test and Texture SSCIs was used for the LFA analysis and was not assessed in the field in 2019. All other parameters were assigned a simple score in the field. Data was entered into the LFA calculation spreadsheets and used to calculate Soil Stability, Soil Infiltration and Nutrient Cycling indices.

A self-sustaining landform is deemed to have been achieved when SSA scores of 50 or more are recorded (the LFA Completion Criteria, expected to be achieved by Year 10 of the management cycle). Incremental improvement toward that target is expected with each year of monitoring. Failure to achieve an increase of five in the annual LFA scores represents a trigger for implementation of the Landscape Stability LFA Trigger Action Response Plan (TARP) described in Table 27 of the BMP (WCPL 2017). Comparative annual results have been colour-coded to provide a visual indicator, with green reaching or exceeding the incremental increase of five or more, and red showing an increase of less than five (or in some cases, a reduction from the previous year). Red coded cells indicate the TARP needs to be implemented. Results maintained at or above the Completion Criteria (50) have been coded green regardless of comparative incremental increase or decrease from previous monitoring.

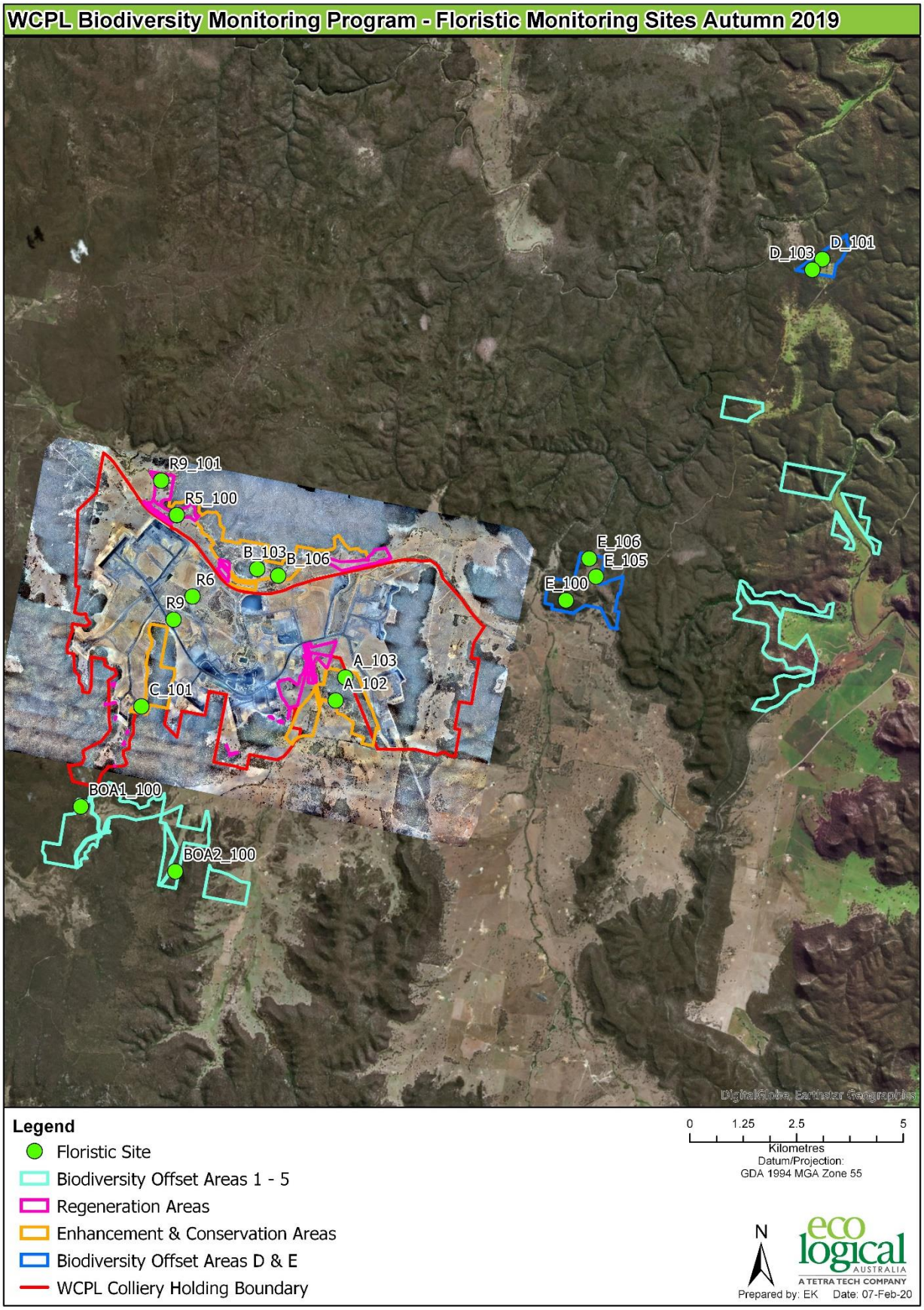

Figure 2: Autumn 2019 vegetation monitoring sites

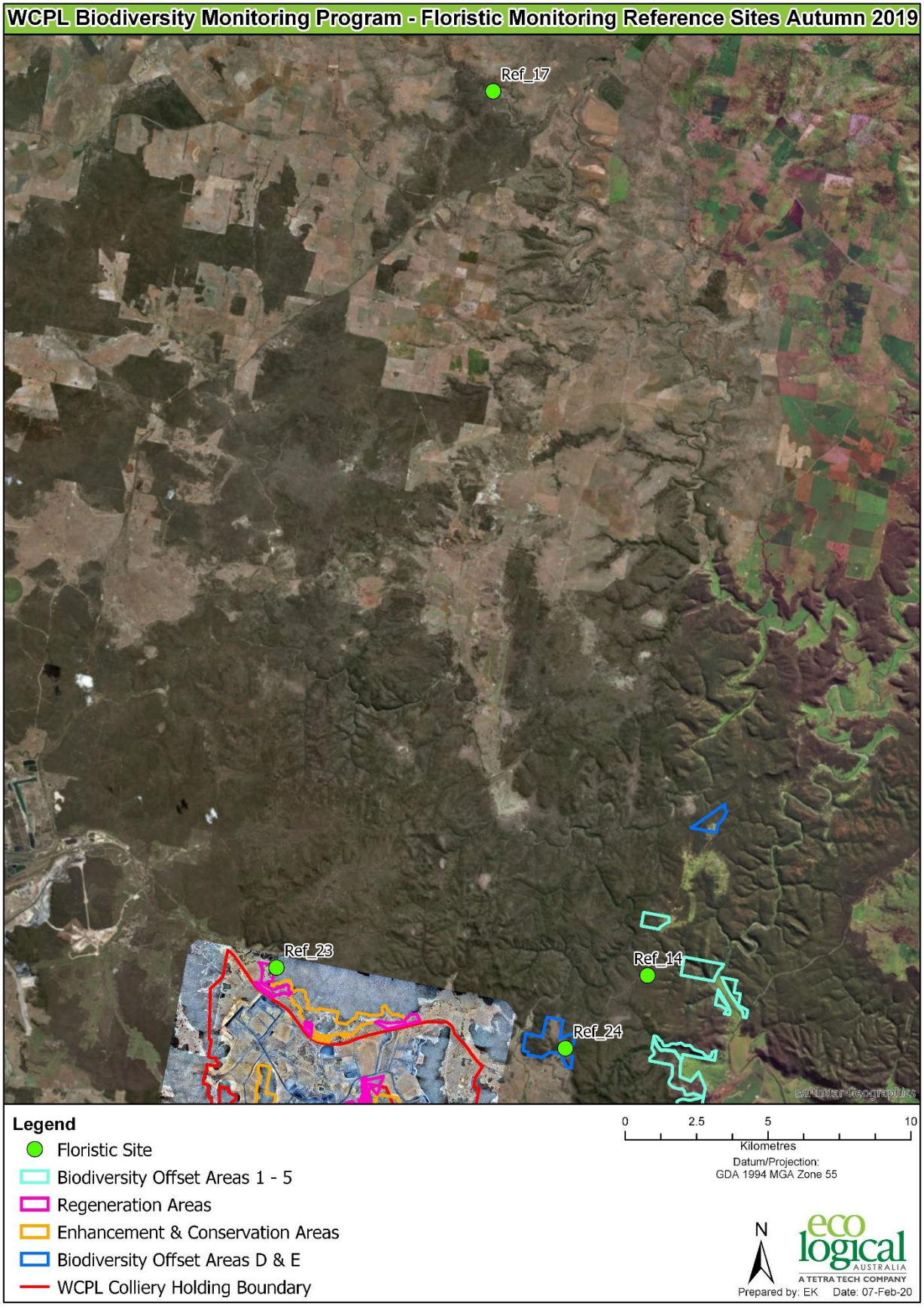

Figure 3: Autumn 2019 vegetation monitoring reference sites

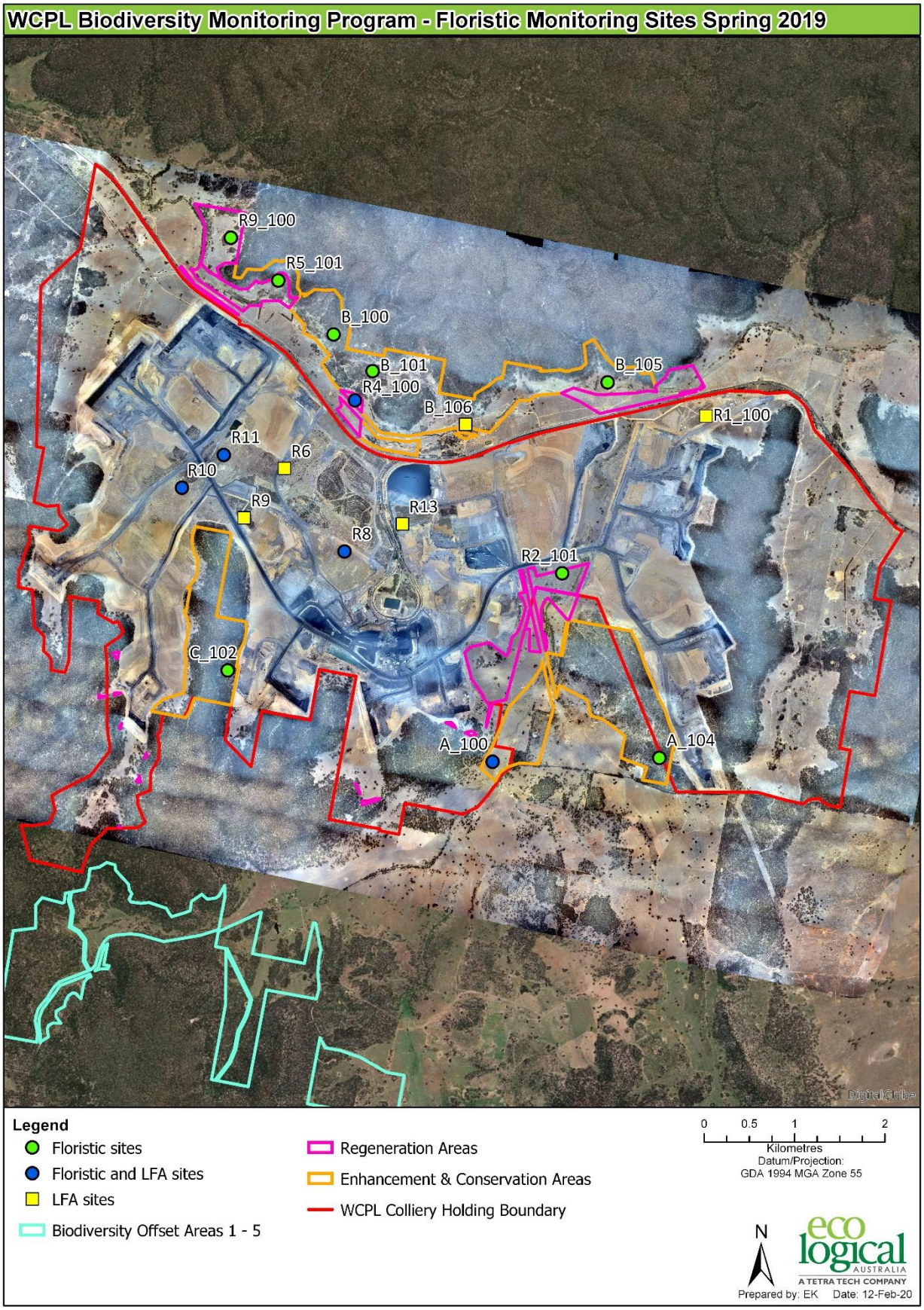

Figure 4: Spring 2019 vegetation and LFA monitoring sites

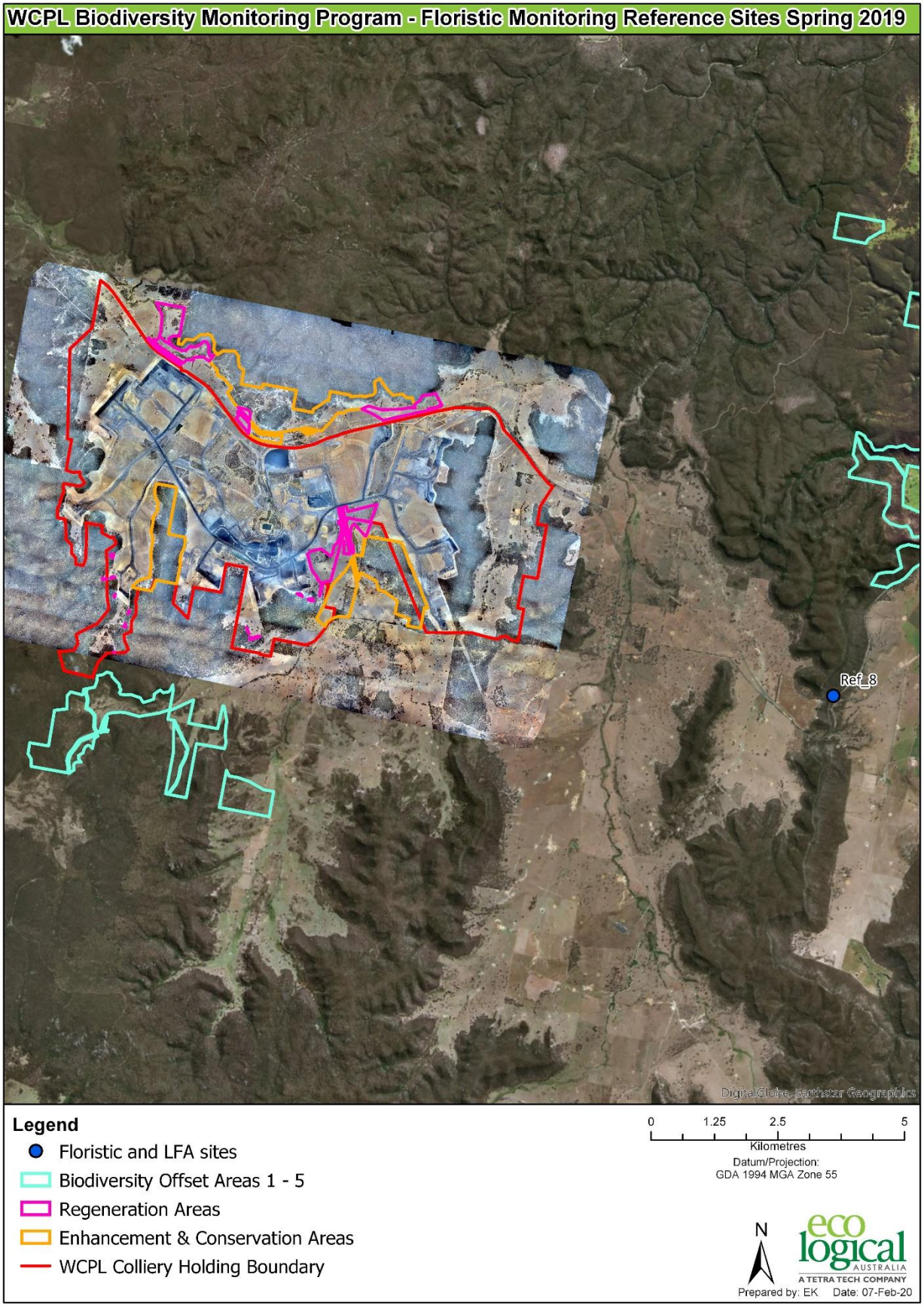

Figure 5: Spring 2019 vegetation and LFA reference sites

2.3 Fauna monitoring

Bird surveys were conducted at all monitoring sites across three seasons (Summer, Winter and Spring) to detect migratory species and specialist feeders. Additional fauna trapping and microbat monitoring was undertaken in Spring at selected sites.

2.3.1 Summer bird monitoring

Summer bird monitoring was undertaken at 37 bird monitoring sites from 19 February to 28 February 2019 by ELA ecologists Rebecca Croake, Elise Keane, Tomas Kelly and Angelina Siegrist, shown below in **Figure 6**. Summer surveys were implemented in 2019 to capture seasonal variation of bird assemblages and therefore forms the first year of monitoring within this season.

2.3.2 Winter bird monitoring

Winter bird monitoring was undertaken at 32 bird monitoring sites from 17 to 21 June and 6 to 13 August 2019 by ELA ecologists Rebecca Croake, Kate Maslen and Angelina Siegrist, shown below in **Figure 7**.

During winter 2018, 13 new bird fauna monitoring sites were established within the BOAs 1 to 5. Data collected in 2018 for these sites formed baseline monitoring, with 2019 forming the second year of monitoring for these sites.

Winter bird surveys were undertaken to identify species that feed on the blossoms of winter-flowering eucalypts and lerps. As such, surveys did not commence until *Eucalyptus albens* (White Box) was observed flowering in the region.

2.3.3 Spring fauna monitoring

Spring fauna monitoring was undertaken between 14 October to 22 November 2019 by ELA ecologists Rebecca Croake, Elise Keane, Kate Maslen and Cheryl O'Dwyer.

During Spring monitoring 2019, there were 17 ground fauna and diurnal bird monitoring sites and nine additional diurnal bird only monitoring sites. This includes the sites within BOAs 1 to 5 established in winter 2018, with 2019 forming the second year of monitoring for these sites. Sites located within BOA D and BOA E were not monitoring during Spring 2019, due to these areas being transferred to National Parks Estate. The locations of fauna monitoring sites are shown in Figure 8. Table 3 below outlines the methodology and survey effort for each target species and is based upon the methods prescribed within the BMP (WCPL 2017).

Microbat monitoring was undertaken at eight general fauna monitoring sites, as required by the BMP (WCPL 2017). Microbat analysis was undertaken by ELA ecologist Dr Rod Armistead, with the analysis report provided in **Appendix D**.

Opportunistic fauna sightings, including fauna evidence such as scats and tracks, were also recorded, where identified across all fauna monitoring sites.

Table 3: Fauna monitoring methods summary (WCPL 2017)

Target species	Methodology	Total Survey Effort
Birds	Bird census consisting of 10 minutes recording all birds seen/heard within 50 m radius of central plot point, and further 10	80 minutes per site (20 minutes per survey, per person, per site), over one morning and one afternoon (37 sites).

Target species	Methodology	Total Survey Effort
	minutes recording all birds seen/heard within balance of a 2 ha plot.	
Ground fauna (amphibians, mammals, reptiles)	Pit fall/funnel trap line of 30 m drift fence and five 20 L buckets/10 funnel traps spaced 5 m apart covering both sides of the drift fence.	Twice daily inspections of traps (morning and afternoon) for five days/four nights (23 sites).
Bats	Automated ultrasonic acoustic recording to identify all bat species occurring.	Recording for 2 nights (6pm – 6am) (10 sites).
All	Any sightings of fauna recorded whilst moving throughout the Project Area and located using a GPS.	Opportunistic
Mammals	Opportunistic collection of scats and observations of tree scratching's, animal tracks and paw prints.	Opportunistic

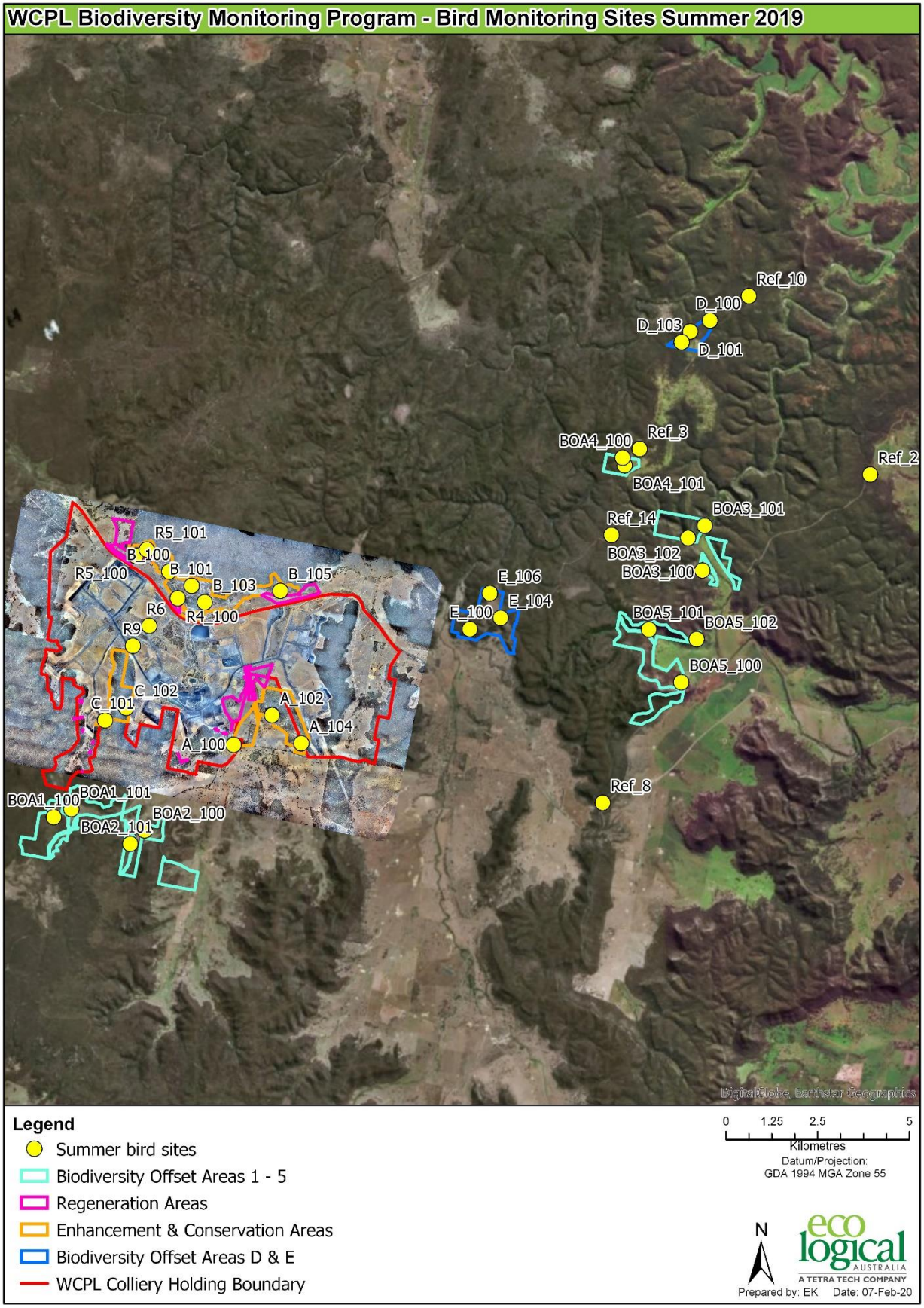

Figure 6: Summer 2019 bird monitoring sites

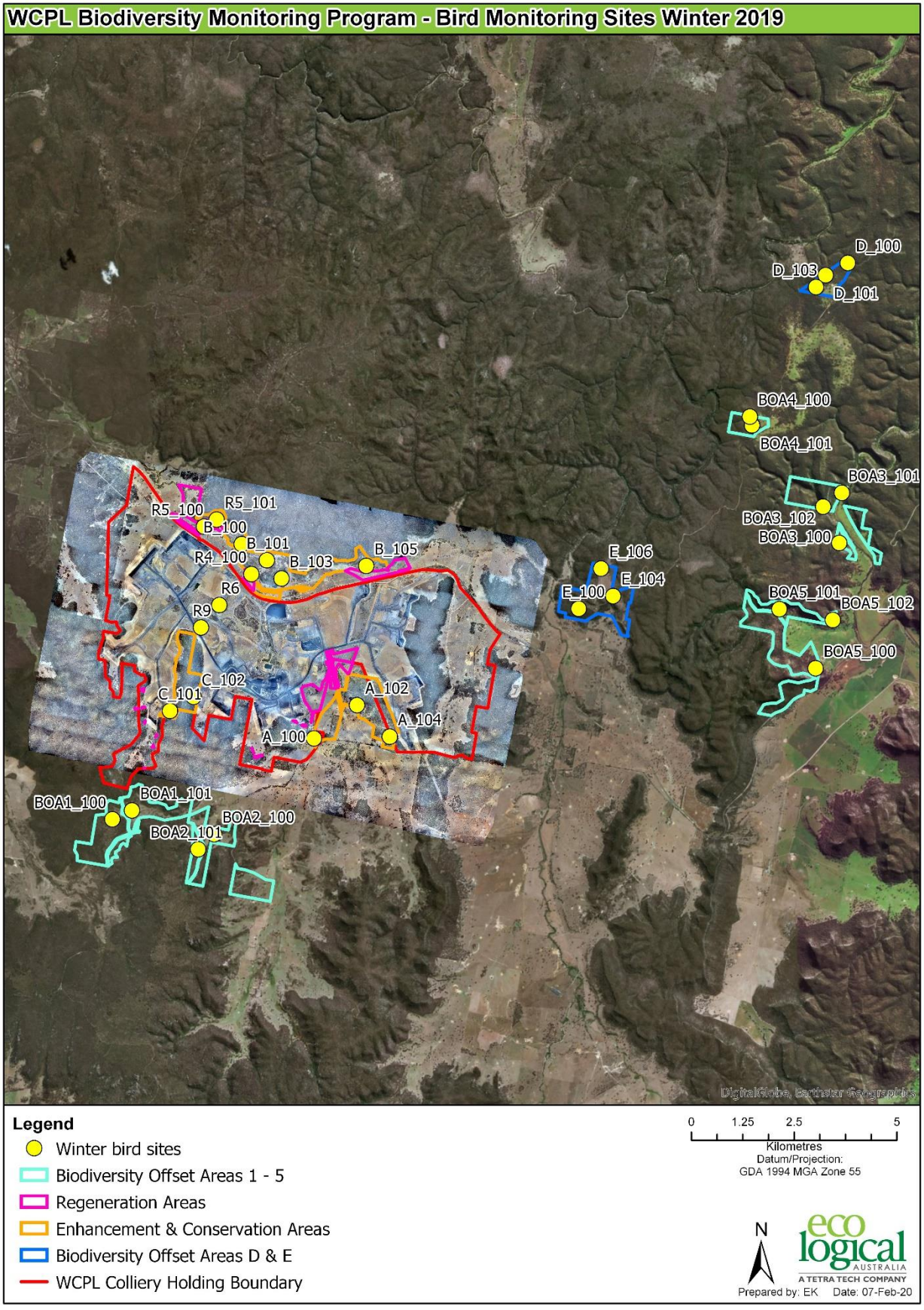

Figure 7: Winter 2019 bird monitoring sites

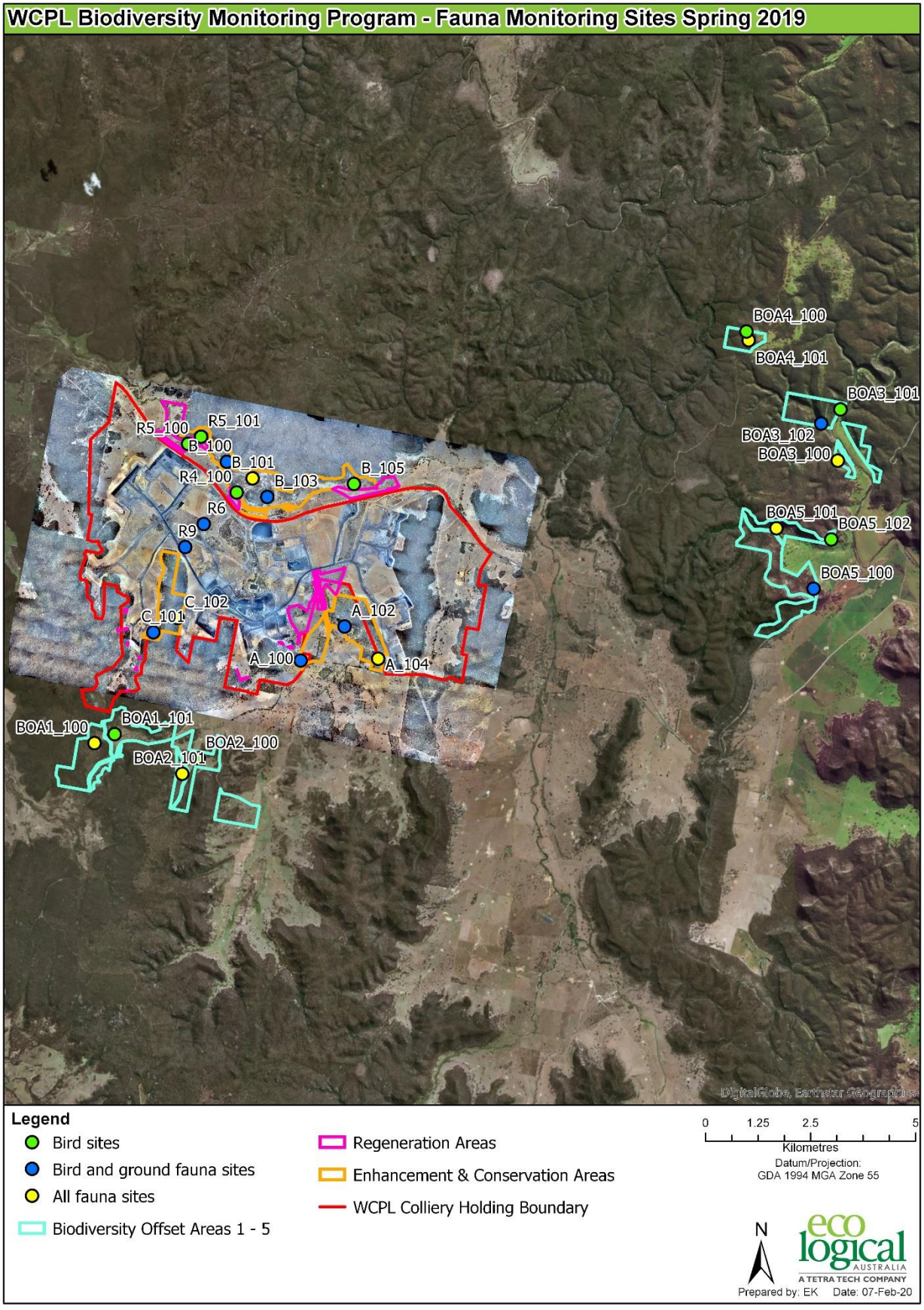

Figure 8: Spring 2019 fauna monitoring sites

3. Results and Discussion

This section presents the 2019 flora and fauna monitoring results, including Autumn and Spring vegetation monitoring, LFA, bird monitoring, and fauna trapping.

3.1 Vegetation monitoring

A total of 250 flora species were recorded across all 34 monitoring and reference sites during Autumn (20 sites) and Spring (14 sites) 2019, consisting of 169 native species and 60 exotic species, with a further 21 species unable to be identified as either native or exotic. The total number of species has declined since 2018, where 321 species was recorded. Trends for NSR, NOC and NMS are presented within **Appendix E**. A full list of all flora species recorded during Autumn and Spring 2019 surveys is included in **Appendix H.**

Exotic species diversity was highest at sites R6, R8 and R11 in 2019, with 44, 38 and 26 species at each site respectively. These sites contain a mix of exotic grass and herb species, which is consistent with previous results.

Weeds classified as priority weeds under the *Central Tablelands Regional Strategic Weed Management Plan 2017 – 2022* (Central Tablelands Local Land Services 2017) were identified at several monitoring sites across the Management Domains. These declared weeds and their site locations are presented below in Table 4. An increase in bare ground during 2019 was noted across most sites – with future rainfall exotic species including *Hypericum perforatum* (St John's Wort) may proliferate within these sites.

Table 4: Declared weeds recorded during 2019

Scientific Name	Common Name	State Priority Weed	Regional Priority Weed	Site	Management domain
Heliotropium amplexicaule	Blue Heliotrope		Y	E_105	BOAs D & E
Hypericum perforatum	St John's Wort		Y	A_100, B_101 R5_101 E-105 R6	ECAs Regeneration Areas BOAs D & E Rehabilitation Areas
Opuntia sp.	Common Pear, Prickly Pear	Y		BOA1_100, E-106 Ref_17, Ref_24	BOAs 1-5 BOAs D & E Reference Areas
Rosa rubiginosa	Sweet Briar		Y	BOA1_100	BOAs 1-5
Rubus fruticosus species aggregate	Blackberry			BOA1_100,	BOAs 1-5

3.1.1 Assessment against Rehabilitation BVT Benchmarks and WCPL Performance Criteria

Vegetation monitoring results for Rehabilitation Area monitoring sites were assessed against the Interim Rehabilitation BVT Benchmarks and WCPL Performance Criteria (see **Appendix F**) which were approved by DPIE on 23 April 2019. These BVT Benchmarks and WCPL Performance Criteria allow for evaluation of Rehabilitation progress towards achieving Completion Criteria, as set out in the revised BMP (WCPL 2019), which is pending approval by DPIE. SVS were calculated to determine the vegetation condition for each site. Rehabilitation sites are being assessed as Year 0, and comparison against these benchmarks is temporary, with WCPL required to define landform establishment, with these sites required to be reworked to the specific BVT communities and species composition.

Table 6 and Table 5 present the individual site attribute and site value scores for each 2019 rehabilitation monitoring site. Table 6 presents comparison of sites against the approved WCPL BVT Performance Criteria and Table 5 presents comparison of sites against OEH BVT Benchmarks (taken from OEH 2017). SVS which do not meet the BVT Benchmark Targets or Performance Criteria are highlighted in red, demonstrating these sites have triggered the Native Vegetation and Habitat Complexity (BioMetric) Trigger TARP detailed in Table 26 of the BMP (WCPL 2017). Amber is not applied to the site value score as anything below the Benchmark Target or Performance Criteria is considered LOW. A colour coding system has been applied to all site attribute results.

- GREEN indicates site attributes that have met the relevant Benchmark Targets or Performance Criteria (indicating that no additional management intervention is required)
- AMBER indicates site attributes that have not met the relevant Benchmark Targets or Performance Criteria, but are within 50 - <100% of the targets
- RED indicates site attributes that are <50% of the relevant Benchmark Targets or Performance Criteria

Table 5: Assessment against Performance Criteria* for Rehabilitation Sites within their respective BVT

BVT	Season	Site	Vegetation condition	SVS	Site attributes (% cover)									
					NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH (Count)	OR	FL (M)
HU824	Autumn	R6	MOD-GOOD-POOR	35	13	0	0.9	0	0	0	44	0	1	0
	Spring	R8	LOW	22	21	0	0	4	0	0	26	0	0	0
	Autumn	R9	MOD-GOOD-GOOD	66	13	6.2	7.3	0	0	0	24	0	1	26
HU732	Spring	R10	MOD-GOOD-POOR	35	7	0	0	0	0	0	8	0	0	15
	Spring	R11	LOW	30	7	0	2	0	0	0	38	0	0	1

SVS = Site Value Score, NSR = Native Plant Species Richness, NOC = Native Overstorey Cover, NMC = Native Midstorey Cover, NGCG = Native Ground Stratum Cover (grasses), NGCS = Native Ground Stratum Cover (shrubs), NGCO = Native Ground Stratum Cover (other), EC = Exotic Plant Cover, NTH = Number of Trees with Hollows, OR = Overstorey Regeneration and FL = Length of Fallen Logs

*Performance Criteria was approved by DPIE on 23 April 2019, and is incorporated into the updated BMP (WCPL 2019), which is pending approval from DPIE

Table 6: Assessment against BVT Benchmarks* for Rehabilitation Sites within their respective BVT

BVT	Season	Site	Vegetation condition	SVS	Site attributes (% cover)									
					NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH (Count)	OR	FL (M)
HU824	Autumn	R6	LOW	18	13	0	0.9	0	0	0	44	0	1	0
	Spring	R8	LOW	11	21	0	0	4	0	0	26	0	0	0
	Autumn	R9	LOW	28	13	6.2	7.3	0	0	0	24	0	1	26
HU732	Spring	R10	LOW	9	7	0	0	0	0	0	8	0	0	15
	Spring	R11	LOW	11	7	0	2	0	0	0	38	0	0	1

SVS = Site Value Score, NSR = Native Plant Species Richness, NOC = Native Overstorey Cover, NMC = Native Midstorey Cover, NGCG = Native Ground Stratum Cover (grasses), NGCS = Native Ground Stratum Cover (shrubs), NGCO = Native Ground Stratum Cover (other), EC = Exotic Plant Cover, NTH = Number of Trees with Hollows, OR = Overstorey Regeneration and FL = Length of Fallen Logs

*BVT Benchmarks are taken from OEH (2017)

BVT Benchmark Targets for Rehabilitation Areas (OEH 2017)

All rehabilitation area sites scored LOW for SVS, with the highest SVS recorded at R9. Across the rehabilitation areas the attributes frequently not meeting the BVT Benchmark were NSR, NOC, NGCG, NGSG, NGCO, NTH and FL. Site R11 met the BVT benchmark for NMC, and sites R6 and R9 met the benchmark for OR. All sites met the benchmark for EC. Comparison against these BVT Benchmarks is temporary until sites are reworked to adhere to their target BVT.

WCPL Performance Criteria for Rehabilitation Areas

There were three sites that scored MOD-GOOD for SVS under the WCPL Performance Criteria. All sites within HU824 met the performance criteria for NSR. Both sites within HU732 met the performance criteria for NMC, as well as site R9. All sites met the performance criteria for EC, NTH and OR. NGCO did not meet the performance criteria at any site across the rehabilitation areas. Comparison against these BVT Performance Criteria is temporary until sites are reworked to adhere to their target BVT.

3.1.2 Assessment against Interim Performance Targets

Vegetation monitoring results for BOAs, ECAs, regenerations areas and reference sites are assessed against the 1-5 year IPTs and Benchmark Targets as set out in the current BMP (WCPL 2017) (see **Appendix G**) and compared against the previous year's monitoring results to evaluate trends and progress towards achieving Completion Criteria, as set out in the BMP (WCPL 2017). All WSGW sites were assessed against the Low condition baseline IPT instead of the vegetation class benchmark condition state defined in the BMP.

SVS were calculated to determine the vegetation condition for each site. Each site was then assessed relative to the IPT or Benchmark targets for the relevant condition within each Keith Vegetation Class as per the BMP (WCPL 2017). Both monitoring periods fall within the Year 1-5 IPTs, being Year 3 (Autumn 2019 sites) and Year 4 (Spring 2019 sites).

Table 7 and Table 8 present the individual site attribute and site value scores for each 2019 monitoring site. SVS which do not meet the IPT are highlighted in red, demonstrating these sites have triggered the Native Vegetation and Habitat Complexity (BioMetric) Trigger TARP detailed in Table 26 of the BMP (WCPL 2017). Amber is not applied to the site value score as anything below the IPT triggers the TARP. A colour coding system has been applied to all site attribute results.

- GREEN indicates site attributes that have met the relevant IPTs (indicating that no additional management intervention is required)
- AMBER indicates site attributes that have not met the relevant IPTs, but are within 50 - <100% of the IPTs and do not show a substantial decrease compared to the previous year's monitoring results (indicating a requirement to monitor closely, management intervention may be required)
- RED indicates site attributes that are <50% of the relevant IPTs or show a substantial decline compared to the previous year's monitoring results (indicating that management intervention is required).

A 'substantial decline' is defined as a relative decline of 50% or greater compared to the previous year's results (e.g. a decline from a value of 20 to a value of 10 or less).

Table 7: Assessment against Interim Performance Targets for WSDSF

Management Domain	Season	Vegetation Community	Site	Vegetation condition	SVS	Site attributes (% cover)									
						NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH (Count)	OR	FL (M)
BOAs D & E	Autumn	WSDSF	D_101	MOD-GOOD	49	23	17	5	0	0	16	0	0	0.5	35
	Autumn	WSDSF	D_103	LOW	30	14	10.5	32[a]	4[a]	4	0	0	0	0	0
	Autumn	WSDSF	E_100	MOD-GOOD	55	31	13	7.5	0	2	2	0	1	0.5	70
BOAs 1-5	Autumn	WSDSF	BOA1_100	MOD-GOOD	70	29	29	15	2	0	2	0	2	0.5	120
	Autumn	WSDSF	BOA2_100	HIGH	81	28	25	13.7	4	0	6	0	4	0.5	120
ECA	Spring	WSDSF	B_105	LOW	8	12	0	0	20[c]	0	0	14	0	0	0
	Autumn	WSDSF	B_103	LOW	30	28	24.5[a]	0.7	0	2	4a	0	0	0.33	0
	Autumn	WSDSF	C_101	LOW	11	6	0	0	20[c]	0	16[c]	16	0	0	0
Regeneration Area	Spring	WSDSF	R5_101	LOW	17	17	0	0	36[c]	0	2	6	0	0	0
	Spring	WSDSF	R9_100	LOW	29	21	0	10.4[a]	22[c]	0	4	0	0	0	0
Reference sites	Autumn	WSDSF	Ref_14	MOD-GOOD	53	25	16.2	7.7	6	4	10	0	0	1	11

SVS = Site Value Score, NSR = Native Plant Species Richness, NOC = Native Overstorey Cover, NMC = Native Midstorey Cover, NGCG = Native Ground Stratum Cover (grasses), NGCS = Native Ground Stratum Cover (shrubs), NGCO = Native Ground Stratum Cover (other), EC = Exotic Plant Cover, NTH = Number of Trees with Hollows, OR = Overstorey Regeneration and FL = Length of Fallen Logs

a: attribute exceeds the low condition 1-5 year IPT and meets the benchmark.

b: attribute does not meet low condition 1-5 year IPT but meets benchmark, coloured orange as lack of ground cover may be caused from extensive bare soil

c: exceeds low and high condition 1-5 year IPT, as there is no overstorey or mid-storey cover

Table 8: Assessment against Interim Performance Targets for WSGW

Management Domain	Season	Vegetation Community	Site	Vegetation condition	SVS	Site attributes (% cover)									
						NSR	NOC	NMC	NGCG	NGCS	NGCO	EC	NTH	OR	FL (M)
BOAs D & E	Autumn	WSGW	E_105	LOW	22	12	0	0	34[b]	0	4	0	0	0	0
	Autumn	WSGW	E_106	MOD-GOOD	23	18	0	0	20[c]	0	6	0	0	0	0
ECA	Spring	WSGW	A_100	LOW	8	4	0	0	4	0	0	6	0	0	0
	Autumn	WSGW	A_102	MOD-GOOD	34	13	0	12	18[c]	0	4	0	0	0	0
	Autumn	WSGW	A_103	HIGH	71	25	22	1.9	8	0	10	0	4	0.67	20
	Spring	WSGW	A_104	MOD-GOOD	49	16	11.7	5.7	2	0	0	0	0	0	65
	Spring	WSGW	B_100	MOD-GOOD	54	26	18.5	3.5	2	2	0	0	0	0.67	22
	Spring	WSGW	B_101	LOW	23	21	0	0	10[b]	0	10[c]	0	0	0	0
	Autumn	WSGW	B_106	LOW	13	11	0	0	36[b]	0	0	0	0	0	0
	Spring	WSGW	C_102	MOD-GOOD	66	27	8.9	3	0	4[e]	0	0	1	0.25	63
Regeneration area	Spring	WSGW	R2_101	LOW	9	10	0	0	10[b]	0	0	14	0	0	0
	Spring	WSGW	R4_100	LOW	5	4	0	0	0	0	0	2	0	0	0
	Autumn	WSGW	R5_100	LOW	21	12	0	0	36[b]	0	0	0	0	0	0
	Autumn	WSGW	R9_101	LOW	14	7	0	0	42[b]	0	2	0	0	0	0
Reference sites	Spring	WSGW	Ref_8	HIGH	91	28	16.5	2.5	6	0	12	0	3	1	68
	Autumn	WSGW	Ref_17	MOD-GOOD	42	31	28	0	10[d]	0	16[e]	0	4	0.33	54
	Autumn	WSGW	Ref_23	LOW	33	17	12.5	0.2	2	0	22[a]	0	0	0.5	5
	Autumn	WSGW	Ref_24	MOD-GOOD	63	27	12.7	2.4	16	0	2	0	1	0.33	34

SVS = Site Value Score, NSR = Native Plant Species Richness, NOC = Native Overstorey Cover, NMC = Native Midstorey Cover, NGCG = Native Ground Stratum Cover (grasses), NGCS = Native Ground Stratum Cover (shrubs), NGCO = Native Ground Stratum Cover (other), EC = Exotic Plant Cover, NTH = Number of Trees with Hollows, OR = Overstorey Regeneration and FL = Length of Fallen Logs

a: attribute exceeds the low condition IPT and meets the benchmark.

b: attribute does not meet low condition IPT but meets benchmark, coloured orange as lack of ground cover may be caused from extensive bare soil

c: attribute does not meet Mod-Good condition IPT but meets benchmark, coloured orange as lack of ground cover may be caused from extensive bare soil

d: attribute does not meet the Mod-Good condition IPT but meets the benchmark.

e: attribute exceeds Mod-Good condition IPT and meets the benchmark.

Western Slopes Dry Sclerophyll forest (WSDSF)

A comparison of attributes monitored across all WSDSF sites is presented in Table 7. Across the ECA areas, the attributes frequently not meeting their respective IPT are the number of Fallen Logs (FL), overstorey regeneration (OR), native ground cover grass (NGCG) and NMC. Regeneration sites are not meeting the IPT for the number of FL and OR. Reference sites monitored during 2019 are compared to the Benchmark targets for their respective vegetation community. Ref_14 has meet seven of the 10 IPT's but has not yet met NSR, NMC and native ground cover shrub (NGCS) benchmarks.

The year 2019 saw an overall decline in SVS, presented in Figure 9. Site R9_101 SVS has declined every year since 2016, while D_101 and Ref_14 has declined every year since 2017. Sites B_105, C_101 and R6 have maintained consistent results.

Western Slopes Grassy Woodland (WSGW)

A comparison of attributes monitored across all WSGW sites is presented in Table 8. Across the ECA areas, the attributes frequently not meeting IPT's are OR and NGCG. Across the regeneration areas the attributes not yet meeting IPT are NGCG, number of FL and OR. Reference sites monitored during 2019 are compared to the Benchmark targets for their respective vegetation community. All but one reference site did not meet OR IPT. All reference sites have not met the NMC and NGCS benchmarks.

As for WSDSF, SVS for sites within WSGW saw an overall decline in SVS in 2019 as can be seen in Figure 10. A downwards trend can be seen in R_10, Ref_17 and Ref_24. Sites R9_100 and Ref_8 have all increased, with 2019 the highest SVS at each of these sites.

3.1.3 Review of IPTs against Trigger Action Response Plans

As per the updated WCPL BMP (WCPL 2017), TARPs have been developed if IPTs are not being met. Table 7 and Table 8 identify those sites with SVS which do not currently meet the 1-5 year IPT and are colour-coded red. This results in 17 of the 29 sites not meeting their IPT and, triggering the Native Vegetation and Habitat Complexity (BioMetric) TARP. All sites are classified within the low vegetation condition trigger the TARP as they all have an IPT of less than 34. The TARP provides a plan to review and monitor all results to improve to targeted levels.

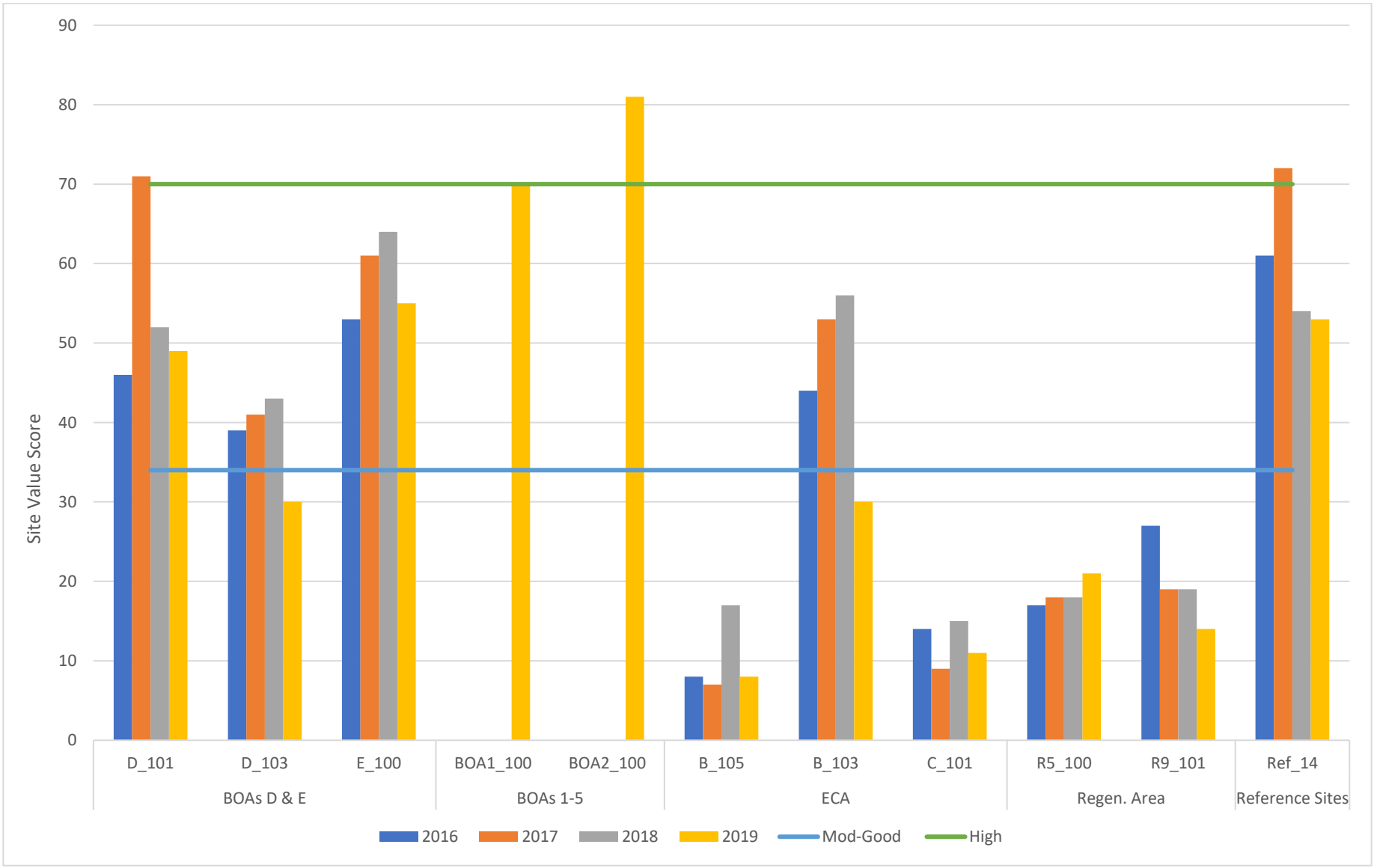

Figure 9: WSDSF Site Value Scores and the Mod-Good and High IPT

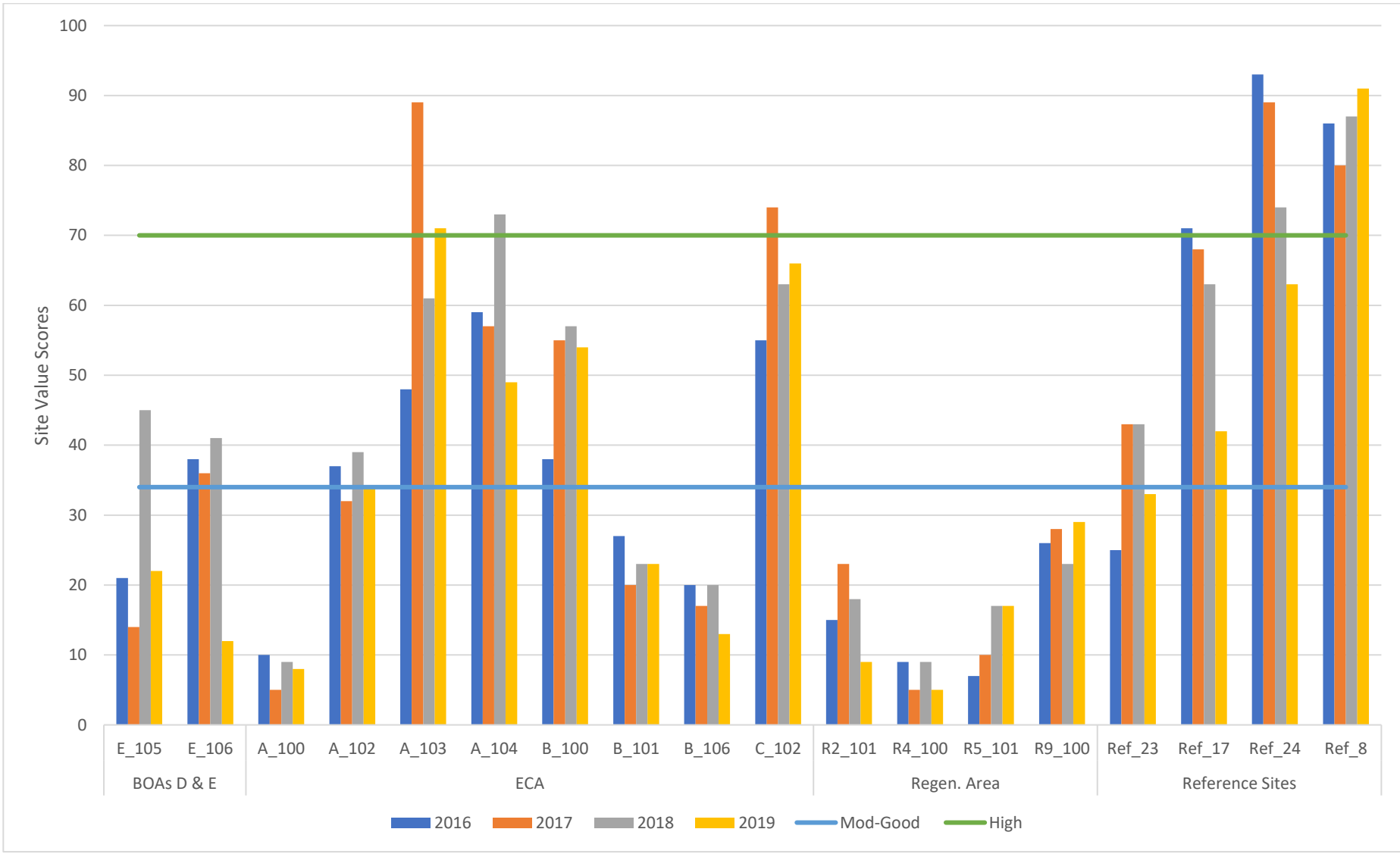

Figure 10: WSGW Site Value Scores and the Mod-Good and High IPT

Exotic flora species

Exotic species results were positive across all BOAs, ECAs and Regeneration Areas monitored during 2019, with all sites achieving the EC IPT (i.e. less than 60 % cover for low condition sites, less than 40 % for moderate sites and less than 20% for high condition sites approaching 5%). Comparison of EC attribute scores compared against the Low, Mod-Good and High IPT are illustrated below in Figure 11 and Figure 12**.** There has been an overall decline in EC within most sites.

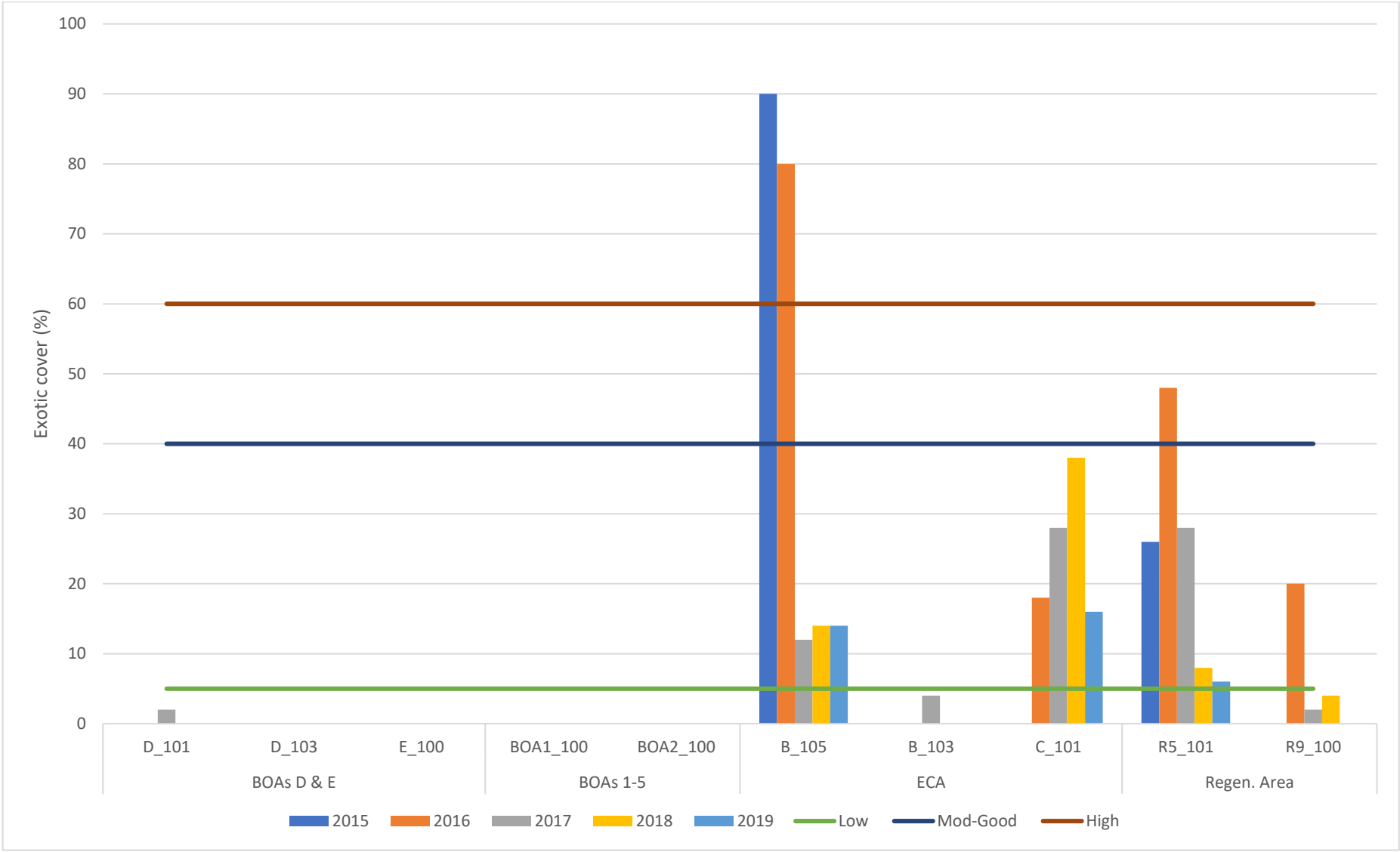

Figure 11: Exotic cover for all sites from 2015 to 2019 compared against the 1-5 year IPT for WSDSF

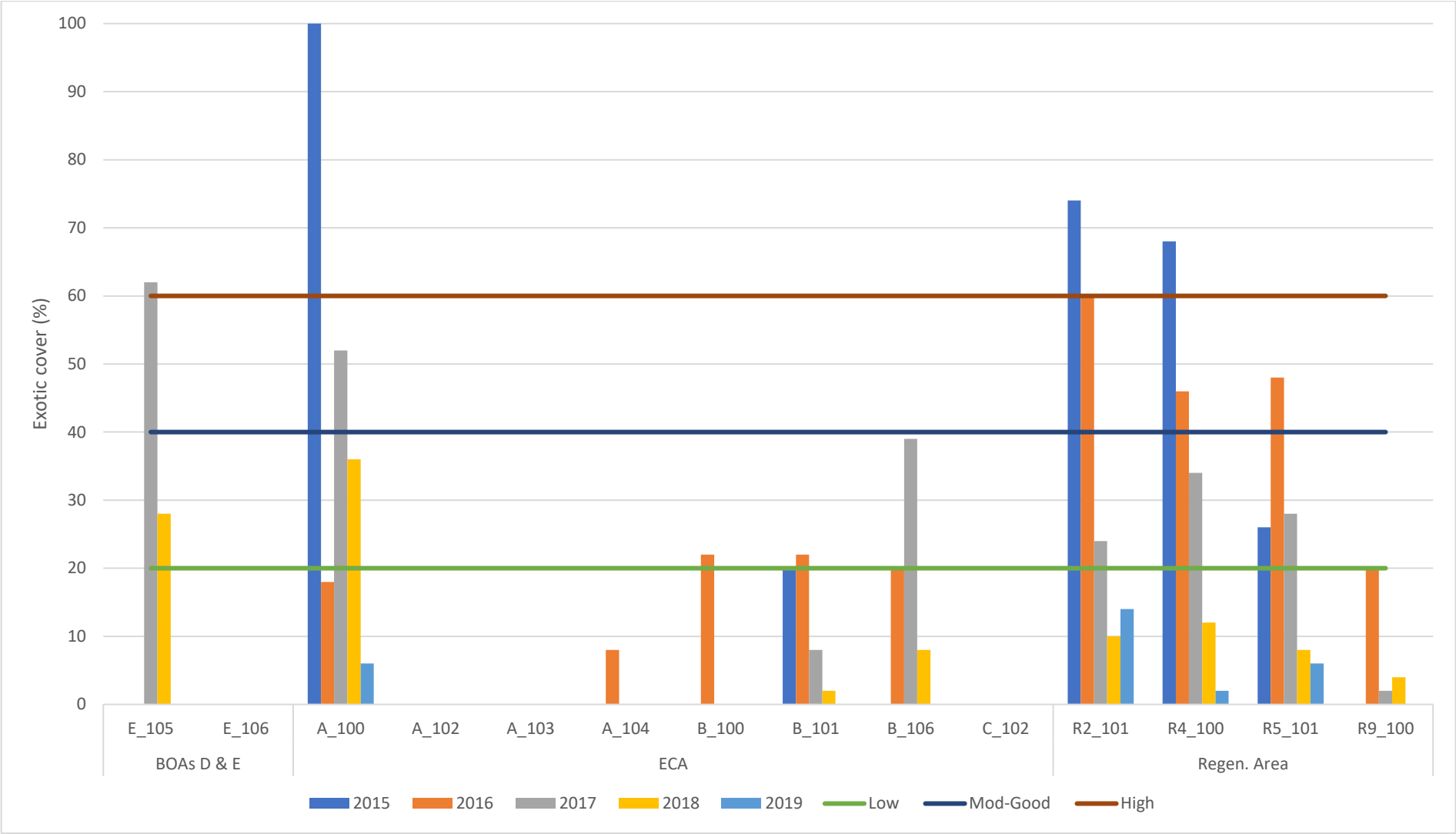

Figure 12: Exotic cover for all sites from 2015 to 2019 compared against the 1-5 year IPT for WSGW

3.2 Landscape Function Analysis

The LOI and SSA scores calculated from Spring 2019 LFA monitoring are presented in Table 9 to Table 12 below. The results are presented as a comparison to the 2018 monitoring data to provide an assessment against the LFA completion criteria**.** It should be noted that there are several contributing factors in the data collection and calculation of scores which may result in minor inconsistencies from year to year. Attributes which are not meeting the annual incremental increase targets, and as such are marked in red, represent a trigger for the Landscape Stability (LFA) TARP outlined in Table 27 of the BMP (WCPL 2017).

3.2.1 Enhancement and Conservation Areas (ECAs)

Two LFA monitoring sites are located within the ECA Management Domains, include site A_100 and site B_106. Both sites are located within regenerating vegetation.

The LOI and SSA results for these sites are presented in Table 9. During Spring 2019 monitoring, site A_100 recorded a LOI of 0.97, being almost entirely covered by perennial ground cover and litter patches, site B_106 recorded a LOI of 0.81, with extensive perennial ground cover and litter patches, and small patches of bare soil, this is a decrease from 2018.

Both ECA sites have met the stability completion criteria during the 2019 monitoring. Site A_100 recorded soil infiltration and nutrient cycling scores below the Completion Criteria target of 50 and decreased from 2018 LFA assessments, while site B_106 is tracking towards the completion criteria.

Table 9: LOI and SSA results for ECA transects

Site	Monitoring Season	Landscape Organisation Index	Soil Surface Assessment		
			Stability	Infiltration	Nutrient Cycling
A_100	Spring 2019	0.97	58.6	38	34.8
	Spring 2018	1.00	49.9	44.5	36.7
		Annual incremental increase	8.7	-6.5	-1.9
B_106	Spring 2019	0.81	61.3	40.8	32.4
	Spring 2018	0.83	57.4	38.4	28.8
		Annual incremental increase	3.9	2.4	3.6

3.2.2 Regeneration Areas

One LFA monitoring site, R4_100, is located within the regeneration area Management Domain. The LOI and SSA results for this site are presented in Table 10.

During Spring 2019 monitoring LOI decreased by 0.3%, with the transects being occupied with perennial groundcover and patches of litter, with small patches of bare soil. The Soil Stability, Soil Infiltration and Nutrient cycling scores have all decreased from monitoring assessments conducted in 2018. Whilst the completion criteria for stability was met in 2018, it has since decreased and is now below the completion criteria target.

Table 10: LOI and SSA results for regeneration area transects

Site	Monitoring Season	Landscape Organisation Index	Soil Surface Assessment		
			Stability	Infiltration	Nutrient Cycling
	Spring 2019	0.73	44.6	27.1	23.9
R4_100	Spring 2018	0.76	52.9	36.2	30.1
		Annual incremental increase	-8.3	-9.1	-6.2

3.2.3 Rehabilitation Areas

Six LFA monitoring sites are located within rehabilitation areas, including R6; R8; R9; R10; R11 and R13. The LOI and SSA results for the sites are presented in Table 11.

Spring 2019 monitoring results indicate that all rehabilitation area transects with exception to R10 experienced a drop in LOI scores in comparison to Spring 2018 results probably due to increasing amounts of bare soil across these sites. The Soil Stability scores recorded at sites R6, R8, R9, R10, and R13 exceeded the Completion Criteria. Site R11 experienced a decline of -4.6 from Spring 2018 and whilst it is currently below the Completion Criteria it is still approaching the score of 50. The Soil Infiltration and Nutrients scores for all the rehabilitation area transects were below the Completion Criteria, although R9 and R10 are tracking towards the Infiltration completion criteria and R9 is tracking towards nutrient cycling.

Table 11: LOI and SSA results for rehabilitation area transects

Site	Monitoring Season	Landscape Organisation Index	Soil Surface Assessment		
			Stability	Infiltration	Nutrient cycling
	Spring 2019	0.31	58.6	30.2	29.7
R6	Spring 2018	0.70	58.5	28.9	28.3
		Annual incremental increase	0.1	1.3	1.4
	Spring 2019	0.80	54.7	21.8	18.1
R8	Spring 2018	0.93	48.0	35.3	28.3
		Annual incremental increase	6.7	-13.5	-10.2
	Spring 2019	0.81	55.7	28.8	26.3
R9	Spring 2018	0.87	56.1	26.4	24.8
		Annual incremental increase	-0.4	2.4	1.5
	Spring 2019	0.71	57.8	27.2	23.9
R10	Spring 2018	0.64	52.0	25.1	22.8
		Annual incremental increase	5.8	2.1	1.1
	Spring 2019	0.94	48.3	22.3	19.1
R11	Spring 2018	0.95	52.9	34.4	31.9
		Annual incremental increase	-4.6	-12.1	-12.8
	Spring 2019	0.81	63.3	26.4	26.7
R13	Spring 2018	0.87	51.5	32.0	30.7
		Annual incremental increase	11.8	-5.6	-4.0

3.2.4 Reference sites

LFA monitoring was undertaken at reference sites to provide comparative data to assist in guiding management of WCPLs Management Domains. Only one reference site was monitored in 2019, Ref_8. The LOI and SSA scores for the reference site transect is presented in Table 12.

During Spring 2019 monitoring, a high LOI score of 1 was recorded at Ref_8 – the site is entirely occupied with patches of perennial ground cover and litter resulting in a stable landform. The Soil Surface Stability score was above the Completion Criteria, however soil Infiltration and Nutrient cycling scores have declined compared to 2018.

Table 12: LOI and SSA results for reference sites

Site	Monitoring Season	Landscape Organisation Index	Soil Surface Assessment		
			Stability	Infiltration	Nutrient cycling
Ref_8	Spring 2019	1.00	62.2	44.8	39.5
	Spring 2018	0.99	59.3	46.9	41.3
		Annual incremental increase	2.9	-2.1	-1.8

3.2.5 Discussion of LFA monitoring results

Most sites recorded relatively high LOI scores (>.80), indicating stable, functioning landform covered by perennial vegetation cover at these sites. LOI scores below 0.80 were recorded at sites R6, R10 and R4_100, due to an increase in patches of bare soil compared to Spring 2018 results, which indicates a decrease in landform stability.

This decrease in stability score could be attributed to increases in average temperatures and below average rainfalls recorded throughout 2019. Drought conditions have been experienced in the Central Tablelands region for three years, with below average rainfall consistently recorded since 2017. This ongoing drought has reduced groundcover at many sites, and consequently bare soil has increase, which has led to a decrease in landform stability. LOI should be considered as an indicator only and the correlation of these scores against vegetation and non-vascular ground cover data (for example, FL) is important to gain a more detailed understanding of the overall functioning of the monitoring sites.

Within each of the Management Domains, the dominant patch types were perennial groundcover, litter and a mixture of perennial groundcover and litter. The dense perennial groundcover at many monitoring sites is reflective of their vegetation type and condition, including regenerating Derived Native Grassland (DNG) of grassy woodland communities.

All sites with exception to R11 and R4_100, met the Completion Criteria target for stability. The stability scores across the Management Domain monitoring sites were comparable to the reference site scores. The changes in stability scores may be attributed to a range of factors, including changes in soil moisture levels affecting individual indicators (for example, surface resistance) or observer variation of field conditions. Larger areas of exposed bare soil within the landscape without litter or cryptogram cover increase the likelihood of erosion therefore these sites would have lower stability scores.

Infiltration and Nutrient Cycling indices were lower, with no site achieving the Completion Criteria target. Sites B_106, R9 and R10 achieved the annual incremental increase for Infiltration, with sites

B_106 and R9 meting the annual incremental increase for nutrient cycling. Ref_8 failed to achieve the benchmark completion criteria, or the annual incremental increase for nutrient cycling and infiltration.

Drought conditions have been experienced across the region, with below average rainfall since 2017. These drier conditions, as well as increased herbivore grazing pressure as a result of the reduction of food sources, have led to a reduction of perennial vegetation and increase in bare soil at most sites in 2019 compared to 2018 monitoring results.

Infiltration is affected by litter decomposition, surface roughness and surface nature. Nutrient Cycling may be affected by perennial vegetation cover, litter cover and extent of decomposition, cryptogam cover and soil surface roughness. An increase in perennial vegetation will improve the nutrient cycling levels. Whilst many LFA sites have moderate to dense cover of perennial vegetation (grasses) and/or high litter cover, there was limited litter decomposition observed and largely uniform soil micro topography. Low soil infiltration and nutrient cycling scores may be due to historical clearing and livestock usage across the BOAs, ECAs and regeneration sites. Low scores recorded within the rehabilitation sites may be due to the compacted artificial soils on which the rehabilitation areas are located.

3.2.6 Review of LFA results against Trigger Action Response Plans

As per the updated WCPL BMP (WCPL 2017), TARPs have been developed in the event that LFA results are not incrementally improving towards the respective Completion Criteria. The TARP provides a plan to review and monitor these sites and increase remedial actions to address declining scores. Whilst LFA results have shown <5% annual improvement from the previous monitoring period, these results are likely due to prolonged drought conditions and as per WCPL TARP Table 27 in the BMP (2017), this influence of climatic conditions on these results, prevents the TARP being triggered.

3.3 Fauna monitoring

Fauna monitoring was undertaken during Summer, Winter and Spring in 2019 across 37 sites (37 in summer, 32 in winter and 26 in Spring). A total species richness of 141 species was recorded in 2019 comprising of 118 birds, one amphibian, 12 reptiles, and 10 positively identified microbat species. Whilst most bird species were found across all monitoring seasons, 19 species were only observed during Summer monitoring, 11 species were only observed during Winter monitoring, and nine species were only observed during Spring surveys, which included two threatened species (*Grantiella picta* (Painted Honeyeater) and *Ninox strenua* (Powerful Owl)). A full list of all fauna species recorded during the 2019 monitoring program is included in **Appendix I**.

3.3.1 Summer bird monitoring

A total of 94 bird species were identified during the 2019 Summer bird monitoring. Bird species richness at individual sites ranged from five species at site R6 to 26 species at site BOA5_101. The most abundant species recorded was *Artamus superciliosus* (White-browed Woodswallow) with a total of 322 individuals recorded across the monitoring sites. The most commonly occurring species was *Cormobates leucophaea* (White-throated Treecreeper), which was recorded at 31 of the 37 monitoring sites. One introduced species was recorded, *Sturnus vulgaris* (Common Starling), with three individuals recorded at site E_106.

Five species listed as vulnerable under the BC Act were identified, including *Artamus cyanopterus* (Dusky Woodswallow), *Calyptorhynchus lathami* (Glossy Black-Cockatoo), *Chthonicola sagittata* (Speckled Warbler), *Climacteris picumnus victoriae* (Brown Treecreeper eastern subsp.) and *Glossopsitta pusilla* (Little Lorikeet) (Table 13). These threatened species were recorded across 14 sites.

Table 13: Summer bird monitoring – threatened species

Scientific Name	Common Name	Site Recorded	BC Act Listing	EPBC Act Listing
Artamus cyanopterus	Dusky Woodswallow	BOA5_100, BOA5_101, Ref_8, BOA1_100	V	-
Calyptorhynchus lathami	Glossy Black-cockatoo	BOA3_101, E_100, Ref_3	V	-
Chthonicola sagittata	Speckled Warbler	R9, BOA3_100, BOA5_102, B_105	V	-
Climacteris picumnus victoriae	Brown Treecreeper eastern subsp.	Ref_2, BOA5_100, BOA5_101, Ref_8, BOA4_100	V	-
Glossopsitta pusilla	Little Lorikeet	Ref_8, D_103, BOA1_100	V	-

3.3.2 Winter bird monitoring

A total of 85 species were observed during the 2019 Winter bird monitoring. These included 11 species that were only recorded during winter bird monitoring. 2019 bird monitoring results have increased from prior monitoring efforts recorded in 2018 by 9 species

The 2019 Winter bird survey was conducted in conjunction with the observation of flowering Winter feed tree species, which included winter-flowering eucalypts and lerps. *Anthochaera phrygia* (Regent Honeyeater) and *Lathamus discolour* (Swift Parrot), which are both listed as either critically endangered or endangered under the EPBC Act and BC Act, and are both known winter-feeding specialists, were not observed. Regent Honeyeaters are known to frequent the area, and a breeding pair were observed within the Goulburn River National Park in Spring 2019 (Kelly pers. obvs.).

Bird species richness at individual sites ranged from six species at site R6 to 27 species at sites BOA3_101 and BOA5_101. The most abundant species recorded was *Lichenostomus chrysops* (Yellow-faced Honeyeater) with a total of 198 individuals recorded across the monitoring sites. This was also the most commonly recorded species, being recorded at 26 of the 32 monitoring sites. There were 100 individuals of the Common Starling recorded during the afternoon bird survey at site R4_100. This was the only site where this introduced species was recorded.

Eight species listed under the BC Act were identified during winter surveys **(**Table 14**)**. Threatened species diversity was higher in winter 2019 compared to previous years monitoring, with the Dusky Woodswallow, and *Stagonopleura guttata* (Diamond Firetail) not detected during winter 2018 monitoring and *Melanodryas cucullate* (Hooded Robin) recorded for the first time in 2019. However, the overall occurrence of threatened species has decreased compared to winter 2018 monitoring, with 12 sites recording threatened species in 2019 compared to 15 in 2018.

Table 14: Winter bird monitoring – threatened species

Scientific Name	Common Name	Site Recorded	BC Act Listing	EPBC Act Listing
Artamus cyanopterus	Dusky Woodswallow	BOA5_100	V	-
Chthonicola sagittata	Speckled Warbler	A_102, B_103, E_104, R5_100, BOA5_101, BOA5_102	V	-
Climacteris picumnus victoriae	Brown Treecreeper (eastern subsp.)	R5_100	V	-
Daphoenositta chrysoptera	Varied Sittella	B_100, E_100, BOA2_100	V	-
Glossopsitta pusilla	Little Lorikeet	D_103, BOA1_100	V	-
Melanodryas cucullata	Hooded Robin	A_102	V	-
Petroica boodang	Scarlet Robin	E_104	V	-
Stagonopleura guttata	Diamond Firetail	E_104	V	-

3.3.4 Spring Fauna monitoring

A total of 99 species were observed during 2019 Spring fauna monitoring. These included 76 birds, one amphibian, 12 reptiles, and 10 positively identified microbats. The most abundant bird species recorded was *Manorina melanocephala* (Noisy Miner) with a total of 105 individuals recorded across the monitoring sites. The most commonly recorded species was the Yellow-faced Honeyeater, being recorded at 21 of the 26 monitoring sites. Bird species diversity at individual sites ranged from eight species at sites R6 and R9 to 28 species a site C_102.

Combining bird diversity across seasons for each site shows that there is an upward trend in increasing bird diversity over time (Figure 13). There is no uniform factor apparent at this stage to explain this trend in increase in bird diversity, with all birds recorded considered typical of the Central Tablelands region. Data was analysed for those sites (A_102 and B_103) which exemplified this trend to determine whether any causal factors were identifiable on a site by site basis. The bird species which represent an increase in diversity at these sites are typical of the region and the habitat present at the sites, and therefore do not identify any particular factor which explains this increase in bird diversity over time.

Microbat species diversity is calculated using only positively identified species and excluded species complexes (where the individual species is unable to be identified), to avoid over-estimating species richness. Microbat species richness ranged from five species at sites BOA1_100, A_104 and C_102 to 10 species at site BOA2_101. *Chalinolobus morio* (Chocolate Wattled Bat) and *Vespadelus vulturnus* (Little Forest Bat) were the most commonly occurring microbat species, positively identified at all eight microbat monitoring sites.

There was one amphibian species recorded during Spring 2019 monitoring, *Limnodynastes dumerilii* (Eastern Banjo Frog) from one site. Amphibian species diversity has been low across all sites and across years averaging two species with a maximum of four species in 2018. This is expected given the reduced rainfall and availability of water necessary for amphibians to complete their lifecycles. Therefore, it is likely amphibian species richness will increase in years of higher rainfall.

Reptile species diversity increased in 2019, with 12 species recorded across all monitoring sites. There has been an increasing trend in the number of species of reptiles observed over the years (up from 7 in 2015 to 12 in 2019). Only one species was observed in 2016, a higher rainfall year (Figure 14). Reptiles are more likely to be observed during periods of high temperatures (Spence-Bailey et. al. 2010) and Summer 2019 was higher than average. Drought conditions continued into 2019, therefore on-going monitoring will be needed to determine if this is a seasonal variation, or a continued trend.

Four bird species and three microbat species listed as vulnerable under the BC Act and / or the EPBC Act were recorded and are listed below in Table 15**.**

Table 15: Spring fauna monitoring – threatened species

Assemblage	Scientific Name	Common Name	Site Recorded	BC Act Listing	EPBC Act Listing
Birds	*Artamus cyanopterus*	Dusky Woodswallow	B_101, BOA5_100	V	-
	Climacteris picumnus victoriae	Brown Treecreeper (eastern subsp.)	BOA2_100	V	-

Assemblage	Scientific Name	Common Name	Site Recorded	BC Act Listing	EPBC Act Listing
	Grantiella picta	Painted Honeyeater	A_102, A_104, BOA2_100, BOA2_101	V	V
	Ninox strenua	Powerful Owl	C_102	V	-
Microbats	*Chalinolobus dwyeri*	Large-eared Pied Bat	BOA1_100, BOA2_101, BOA3_100, BOA4_101, BOA5_101, B_101, C_102	V	V
	Miniopterus orianae oceanensis	Large Bentwing Bat	BOA1_100, BOA2_101, BOA3_100, BOA4_101, BOA5_101, B_101, C_102 (Also potentially present at A_104)	V	-
	Vespadelus troughtoni	Eastern Cave Bat	BOA2_101, BOA5_101, B_101	V	-

V = Vulnerable

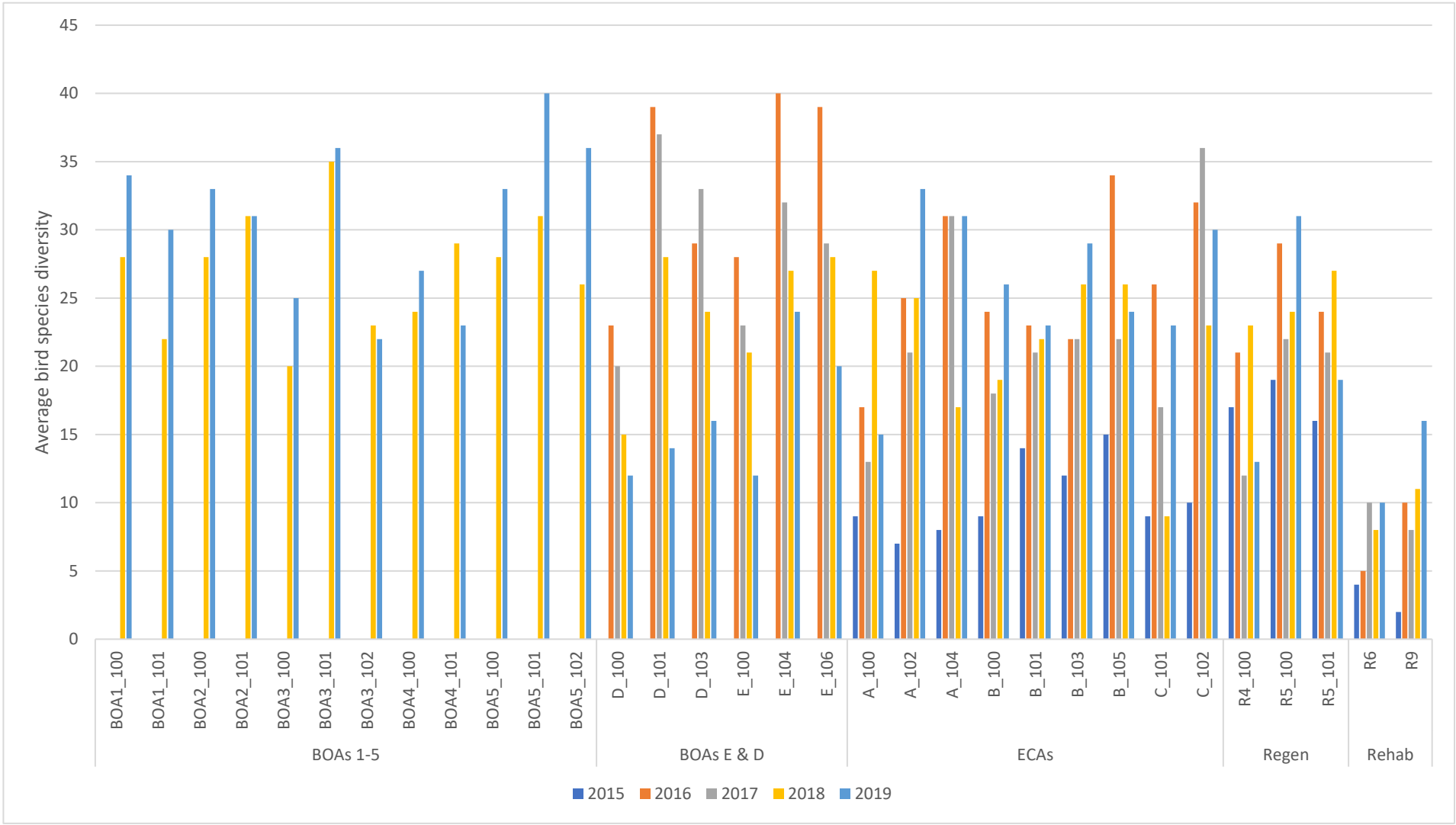

Figure 13: Combined Winter and Spring bird species diversity at monitoring sites 2015 – 2019.

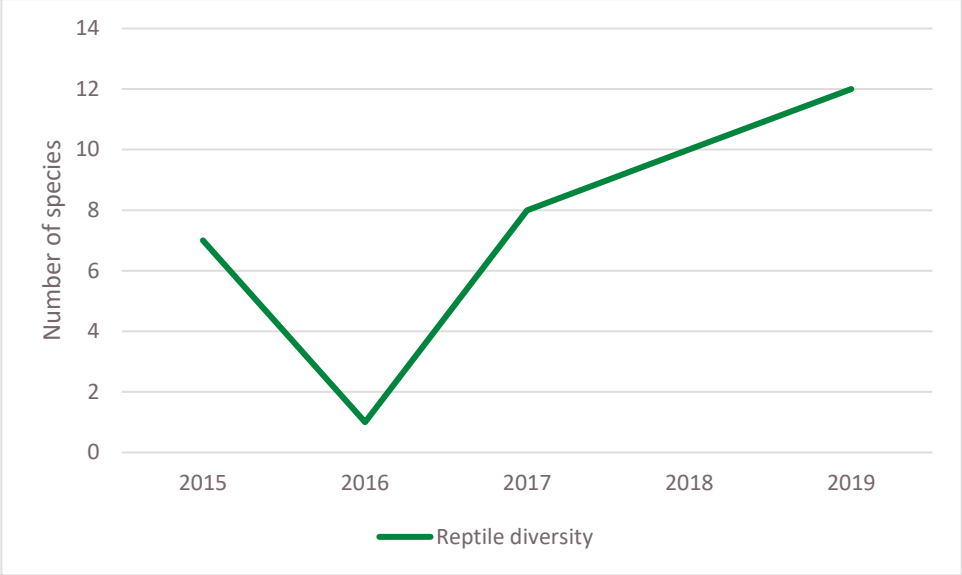

Figure 14: Reptile species diversity across all monitoring sites Spring 2015 - 2019

3.3.5 Overall bird diversity

Species diversity during Winter and Spring across all management domains has increased. A total of 114 species were recorded within Winter and Spring 2019, compared to 112 species recorded within Winter and Spring 2018. Overall species diversity during 2019 comprised of 118 bird species, 12 reptile species, one amphibian species and 10 positively identified microbat species. A full list of all fauna species recorded during the Summer, Winter and Spring 2019 monitoring program is included in **Appendix I**.

Bird diversity across the BOAs has generally increased in 2019 compared to 2018 results. As 2019 forms the second year of monitoring for these sites, ongoing monitoring is recommended to collect more data and determine trends. Bird diversity across the ECA sites and rehabilitation sites has fluctuated throughout monitoring years. Most sites recorded an increase in diversity in 2016, attributable to above average rainfall recorded, but there is an overall upward trend across the majority of the sites. Regeneration sites R4_100 and R5_101, which are both located near creek lines, decreased in diversity in 2019. Sections of the creek were dry due to ongoing drought conditions in the region. Lack of water has also reduced plant growth, reduced flowering and seeding which are all important resources for fauna. It is probable that bird diversity will increase at these sites after rainfall. Both rehabilitation sites (R6 and R9) have increased in bird diversity over the years which is likely to be due to the improvements in vegetation and feed resources including increased flowering and seeding. Ongoing monitoring will determine if this is a continued trend toward habitat improvement at these sites.

3.3.6 Biodiversity Offset Areas 1-5

Total recorded species diversity across BOAs 1 to 5 was 115 species, comprising of 95 birds, ten microbats, nine reptiles and one amphibian species. Three threatened microbat species were recorded across the BOAs, *Chalinolobus dwyeri* (Large-eared Pied Bat), *Miniopterus orianae oceanensis* (Large-Bentwing Bat) and *Vespadelus troughtoni* (Eastern Cave Bat). The results of microbat monitoring undertaken across BOA 1 to 5 during Spring 2019 monitoring is presented below in Table 16. More detailed results from fauna monitoring are discussed per BOA below.

Bird diversity in 2019 has remained stable, with most sites slightly increasing compared to 2018 results (Figure 13). 2019 forms the second year of monitoring at BOAs 1-5, therefore further ongoing monitoring is required before trends can be extracted.

Table 16: Results of the microbat analysis for BOAs 1 – 5 Spring 2019

Species Name	Common Name	BOA1_100	BOA2_101	BOA3_100	BOA4_101	BOA5_101
Austronomus australis	White-striped Free-tailed Bat		D			
Chalinolobus dwyeri**1	**Large-eared Pied Bat**	D	D	D	D	D
Chalinolobus gouldii	Gould's Wattled Bat		D	D	D	D
Chalinolobus gouldii / *Ozimops* species complex	Gould's Wattled Bat / Free-tailed Bat complex		D	D	D	D
Chalinolobus gouldii / *Scotorepens balstoni*	Gould's Wattled Bat / Inland Broad-nosed Bat	D	D		D	
Chalinolobus morio	Chocolate Wattled Bat	D	D	D	D	D

Species Name	Common Name	BOA1_100	BOA2_101	BOA3_100	BOA4_101	BOA5_101
Chalinolobus morio / ***Vespadelus troughtoni****	Chocolate Wattled Bat / **Eastern Cave Bat**		D	D		D
Chalinolobus morio / ***Vespadelus troughtoni**** / *Vespadelus vulturnus*	Chocolate Wattled Bat / **Eastern Cave Bat** / Little Forest Bat	D	D	D	D	D
Chalinolobus morio / *Vespadelus vulturnus*	Chocolate Wattled Bat / Little Forest Bat				D	
Miniopterus orianae oceanensis*	**Large Bentwing Bat**	D	D	D	D	D
Miniopterus orianae oceanensis* and any or all of the following species, *Vespadelus darlingtoni* / *Vespadelus regulus* / *Vespadelus vulturnus*	Large Bentwing Bat and any or all of the following species, Large Forest Bat / Southern Forest Bat / Little Forest Bat	D	D	D	D	D
Nyctophilus spp. In this region *N. geoffroyi, N. gouldii* and the threatened ***N. corbeni****[1] are likely to be present.	In this region Gould's, Lesser, and the threatened **Corben's Long-eared Bat is** likely to be present.	D	D			D
Ozimops species complex. In this region the *O. petersi*, *O. ridei* and *O. planiceps*.	In this region Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	D	D	D	D	D
Rhinolophus megaphyllus	Eastern Horseshoe Bat	D	D	D	D	D
Scotorepens balstoni	Inland Broad-nosed Bat		D	D		D
Scotorepens greyii	Little Broad-nosed Bat		P			P
Vespadelus darlingtoni	Large Forest Bat		D			
Vespadelus darlingtoni / *Vespadelus vulturnus*	Large Forest Bat / Little Forest Bat		D			
Vespadelus regulus / *Vespadelus vulturnus*	Southern Forest Bat / Little Forest Bat		D	D	D	D
Vespadelus troughtoni*	**Eastern Cave Bat**		D			D
Vespadelus troughtoni* / *Vespadelus vulturnus*	**Eastern Cave Bat** / Little Forest Bat	D	D	D	D	D
Vespadelus vulturnus	Little Forest Bat	D	D	D	D	D

D = DEFINITELY RECORDED, P = POTENTIALLY RECORDED. * LISTED AS THREATENED UNDER THE BC ACT AND 1 LISTED AS THREATENED UNDER THE EBPC ACT

3.3.6.1 Biodiversity Offset Area 1 (BOA 1)

BOA 1 is surrounded on three sides by Munghorn Gap Nature Reserve. There is evidence of past timber harvesting, the valley floor has been mostly cleared with remnants of *Angophora floribunda* (Rough-barked Apple) and *Eucalyptus blakelyi* (Blakely's Red Gum). There are no signs of recent livestock grazing (Peabody 2019). There are two fauna sites within BOA 1, both located within a woodland / forested area. The results of fauna species diversity within BOA 1 are shown in Table 17**.**

There were two bird species listed as vulnerable under the BC Act recorded within BOA 1 in 2019. These species were Dusky Woodswallow and Little Lorikeet, with both species recorded during Summer surveys, and the later also recorded during winter surveys. Two microbat species listed as vulnerable under the BC Act and/or EPBC Act were recorded within BOA 1, Large-eared Pied Bat and Large Bentwing Bat.

Table 17: Fauna species diversity within BOA 1 across 2019 monitoring

Season		BOA1_100	BOA1_101
Summer	Birds	19	21
Winter	Birds	24	19
Spring	Birds	22	23
	Reptiles	2	
	Microbats	5	
	Amphibians	1	
Combined species diversity		46	36

3.3.6.2 Biodiversity Offset Area 2 (BOA 2)

The western boundary of BOA 2 adjoins Munghorn Gap Nature Reserve. Approximately 55% is vegetation, a large amount being advanced regeneration from prior clearing. There are several natural Springs within the area. BOA 2 has been recently grazed by livestock (Peabody 2019). There are two fauna sites within BOA 2, both located within woodland / forested area. The results of fauna species diversity within BOA 2 are shown in Table 18**.**

There were three bird species listed as vulnerable under the BC Act recorded within BOA 2, Brown Treecreeper, *Daphoenositta chrysoptera* (Varied Sittella) and Painted Honeyeater, with the later also listed as vulnerable under the EPBC Act. Three microbat species listed as vulnerable under the BC Act and/or EPBC Act were recorded within BOA 2, Large-eared Pied Bat, Large Bentwing Bat and Eastern Cave Bat. BOA2_101 had the highest reptile diversity across all monitoring sites, recording four different species.

Table 18: Fauna species diversity within BOA 2 across 2019 monitoring

Season		BOA2_100	BOA2_101
Summer	Birds	23	20
Winter	Birds	15	17
Spring	Birds	25	24

Season		BOA2_100	BOA2_101
	Reptiles		4
	Microbats		10
Combined species diversity		41	50

3.3.6.3 Biodiversity Offset Area 3 (BOA 3)

BOA 3 consists of high ridges and sandstone escarpments with numerous caves and shelters. This area is surrounded on three sides by the Goulburn River National Park. Approximately 75% is vegetated, most of which is largely undisturbed. There is an area of old growth dry rainforest dominated by *Backhousia myrtifolia* (Grey Myrtle). It is partially grazed by livestock in more cleared areas (Peabody 2015). There are three fauna sites within BOA 3, located within woodland / forest areas. The results of fauna species diversity within BOA 3 are shown in Table 19.

There were two bird species listed as vulnerable under the BC Act recorded within BOA 3, Glossy Black-Cockatoo and Speckled Warbler. Both species were recorded during Summer monitoring. Two microbat species listed as vulnerable under the BC Act and/or EPBC Act were recorded within BOA 3, Large-eared Pied Bat and Large Bentwing Bat.

Table 19: Fauna species diversity within BOA 3 across 2019 monitoring

Season		BOA3_100	BOA3_101	BOA3_102
Summer	Birds	20	23	6
Winter	Birds	16	27	12
Spring	Birds	14	23	15
	Reptiles	2		1
	Microbats	7		
Combined species diversity		42	43	28

3.3.6.4 Biodiversity Offset Area 4 (BOA 4)

BOA 4 is surrounded on three sides by the Goulburn River National Park. The land is generally flat with a central incised gully system extending to the west. There are low sandstone escarpments along this system. There are no signs of recent livestock grazing (Peabody 2019). There are two fauna sites within BOA 4, located within woodland / forest areas. The results of fauna species diversity within BOA 4 are shown in Table 20.

There was one bird species listed as vulnerable under the BC Act recorded within BOA 4, Brown Treecreeper, which was recorded during Summer monitoring. Two microbat species listed as vulnerable under the BC Act and/or EPBC Act were recorded within BOA 4, Large-eared Pied Bat and Large Bentwing Bat.

Table 20: Fauna species diversity within BOA 4 across 2019 monitoring

Season		BOA4_100	BOA4_101
Summer	Birds	18	22

Season		BOA4_100	BOA4_101
Winter	Birds	19	17
Spring	Birds	16	13
	Reptiles		3
	Microbats		6
Combined species diversity		32	41

3.3.6.5 Biodiversity Offset Area 5 (BOA 5)

This area is surrounded on three sides by the Goulburn River National Park. Over 80% is vegetated, with evidence of some prior clearing and timber harvesting. This BOA consists of colluvial lower slopes surrounding an alluvial cultivated valley floor. It is partially grazed by livestock in more cleared areas (Peabody 2015). There are three fauna sites located within BOA 5, located within woodland / forest areas. The results of fauna species diversity within BOA 5 are shown in Table 21**.**

There were three bird species listed as vulnerable under the BC Act recorded within BOA 5, Brown Treecreeper, Dusky Woodswallow and Speckled Warbler. Three microbat species listed as vulnerable under the BC Act and/or EPBC Act were recorded within BOA 5, Large-eared Pied Bat, Large Bentwing Bat and Eastern Cave Bat.

Table 21: Fauna species diversity within BOA 5 across 2019 monitoring

Season		BOA5_100	BOA5_101	BOA5_102
Summer	Birds	22	26	22
Winter	Birds	17	27	24
Spring	Birds	20	27	25
	Reptiles		1	
	Microbats		8	
Combined species diversity		42	57	39

3.3.7 Enhancement and Conservation Areas

Total species diversity across the ECAs was 90 species, comprised of 75 birds, nine microbats and six reptiles. Three threatened microbats were detected across the ECA areas. The results of microbat monitoring undertaken across ECA-A, ECA-B and ECA_C during Spring 2019 monitoring is presented in Table 22. More detailed results from fauna monitoring are discussed per ECA below.

Bird diversity over Winter and Spring has increased at all sites in 2019 compared to 2018 results, with the exception of A_100 and B_105, which decreased. Across all monitoring years, bird diversity within the ECAs has fluctuated, with most sites recording high diversity in 2016. This could be due to the above average rainfall recorded in 2016 resulting in increased food sources.

Table 22: Results of the microbat analysis for A_104, B_101 and C_102 Spring 2019

Species Name	Common Name	A_104	B_101	C_102
Austronomus australis	White-striped Free-tailed Bat	D	D	-
***Chalinolobus dwyeri**[1]*	**Large-eared Pied Bat**	-	D	D
Chalinolobus gouldii	Gould's Wattled Bat	D	D	D
Chalinolobus gouldii / Ozimops species complex	Gould's Wattled Bat / Free-tailed Bat complex	D	D	D
Chalinolobus gouldii / Ozimops species complex / Scotorepens balstoni	Gould's Wattled Bat / Free-tailed Bat complex / Inland Broad-nosed Bat	D	D	D
Chalinolobus gouldii / Scotorepens balstoni	Gould's Wattled Bat / Inland Broad-nosed Bat	D	D	-
Chalinolobus morio	Chocolate Wattled Bat	D	D	D
*Chalinolobus morio / **Miniopterus orianae oceanensis*** / Vespadelus vulturnus*	Chocolate Wattled Bat / **Large Bentwing Bat** / Little Forest Bat	-	-	-
*Chalinolobus morio / **Vespadelus troughtoni***	Chocolate Wattled Bat / **Eastern Cave Bat**	-	D	-
*Chalinolobus morio / **Vespadelus troughtoni*** / Vespadelus vulturnus*	Chocolate Wattled Bat / **Eastern Cave Bat** / Little Forest Bat	D	D	-
Chalinolobus morio / Vespadelus vulturnus	Chocolate Wattled Bat / Little Forest Bat	-	-	-
Miniopterus orianae oceanensis*	**Large Bentwing Bat**	P	D	D
Miniopterus orianae oceanensis* and any or all of the following species, *Vespadelus darlingtoni / Vespadelus regulus / Vespadelus vulturnus*	Large Bentwing Bat and any or all of the following species, Large Forest Bat / Southern Forest Bat / Little Forest Bat	D	D	D
Nyctophilus spp. In this region *N. geoffroyi*, *N. gouldii* and the threatened ***N. corbeni**[1]* are likely to be present.	In this region Gould's, Lesser, and the threatened **Corben's Long-eared Bat is** likely to be present.	-	D	-
Ozimops species complex. In this region the *O. petersi*, *O. ridei* and *O. planiceps*.	In this region Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	D	D	D
Rhinolophus megaphyllus	Eastern Horseshoe Bat	D	-	-
Scotorepens balstoni	Inland Broad-nosed Bat	-	D	-
Scotorepens greyii	Little Broad-nosed Bat	-	-	-
Vespadelus darlingtoni	Large Forest Bat	-	-	-
Vespadelus darlingtoni / Vespadelus vulturnus	Large Forest Bat / Little Forest Bat	-	D	-
Vespadelus regulus / Vespadelus vulturnus	Southern Forest Bat / Little Forest Bat	-	D	-
Vespadelus troughtoni*	**Eastern Cave Bat**	-	D	-

Species Name	Common Name	A_104	B_101	C_102
Vespadelus troughtoni* / *Vespadelus vulturnus*	**Eastern Cave Bat** / Little Forest Bat	D	D	-
Vespadelus vulturnus	Little Forest Bat	D	D	D

D = DEFINITELY RECORDED, P = POTENTIALLY RECORDED. * LISTED AS THREATENED UNDER THE BC ACT AND 1 LISTED AS THREATENED UNDER THE EBPC ACT

3.3.7.1 Enhancement and Conservation Area A (ECA-A)

Sections of ECA-A contain low floristic and forage resource diversity as the site is situated in a cleared paddock with no canopy and/or minimal shrub layer foliage, although a small portion of the site has a high abundance canopy coverage. Landscape features within ECA-A provided habitat for a range of fauna assemblages. The results of fauna species diversity within ECA-A are shown in Table 23.

There were three bird species listed as vulnerable under the BC Act recorded within ECA-A, Hooded Robin, Painted Honeyeater and Speckled Warbler. Painted Honeyeater is also listed as vulnerable under the EPBC Act.

Table 23: Fauna species diversity within ECA-A across 2019 monitoring

Season		A_100	A_102	A_104
Summer	Birds	17	15	20
Winter	Birds	8	16	19
Spring	Birds	12	20	20
	Reptiles			2
	Microbats			5
Combined species diversity		23	37	42

3.3.7.2 Enhancement and Conservation Area B (ECA-B)

ECA-B is located immediately south of the Goulburn River National Park, providing enhanced habitat values for the area through landscape connectivity. Most of the sites have dominant canopy coverage, with litter cover and the presence of FL providing further habitat values for ground fauna. Parts of this area has been extensively cleared. A creek line borders the southern and western edges of the site which contain abundant macrophytes including *Phragmites australis* and scattered canopy coverage. The results of fauna species diversity within ECA-B are shown in Table 24.

There were three bird species listed as vulnerable under the BC Act recorded within ECA-B, Dusky Woodswallow, Speckled Warbler and Varied Sittella. Three microbat species listed as threatened under the BC Act and/or EPBC Act were recorded within ECA-B, Large-eared Pied Bat, Large Bentwing Bat and Eastern Cave Bat.

Table 24: Fauna species diversity within ECA-B across 2019 monitoring

Season		B_100	B_101	B_103	B_105
Summer	Birds	20	19	15	21

Season		B_100	B_101	B_103	B_105
Winter	Birds	22	10	16	16
Spring	Birds	13	18	19	17
	Reptiles	1		3	
	Microbats		8		
Combined species diversity		34	39	35	30

3.3.7.3 Enhancement and Conservation Area C (ECA-C)

Across the monitoring sites within this domain, landscape features provide habitat for a range of fauna assemblages. ECA-C is located adjacent to Munghorn Gap Nature Reserve, which provides enhanced habitat values for the area, through landscape connectivity. Site C_101 is located within DNG, whilst site C_102 is located in remnant eucalypt / cypress pine forest. The results of fauna species diversity within ECA-C are shown in Table 25.

There was one bird species listed as vulnerable under the BC Act recorded within ECA-C, Powerful Owl, which was recorded during Spring surveys. Two microbat species listed as vulnerable under the BC Act and/or EPBC Act were recorded within ECA-C.

Table 25: Fauna species diversity within ECA-C across 2019 monitoring

Season		C_101	C_102
Summer	Birds	6	15
Winter	Birds	9	11
Spring	Birds	18	28
	Reptiles	1	
	Microbats	5	
Combined species diversity		31	36

3.3.8 Regeneration Areas

Total bird species diversity across the regeneration areas was 46 bird species. Two of the three regeneration sites monitored in 2019 decreased in bird diversity compared to 2018 results, however there is still an upward trend overtime. The third site, R5_100, recorded the highest result across all monitoring years (Figure 13).

More detailed results from fauna monitoring are discussed per regeneration area below.

3.3.8.1 Regeneration Area 4

Regeneration Area 4 is located south of the Goulburn River National Park. Creek lines border the site to the north and east. Site R4_100 is located within a regeneration paddock, with cover dominated by the exotic grasses *Phalaris aquatica* and *Vulpia* sp., and a high abundance of exotic forbs. The results of fauna species diversity within regeneration area 4 are shown in Table 26.

Table 26: Fauna species diversity within Regeneration Area 4 across 2019 monitoring

Season	R4_100
Summer	11
Winter	9
Spring	9
Combined bird diversity	18

3.3.8.2 Regeneration Area 5

Regeneration Area 5 is located immediately south of Goulburn River National Park, which provides enhanced habitat values for the area through landscape connectivity. The site is comprised of moderate floristic and forage resource diversity with a scattered canopy coverage on the edge of the site. Both sites in this Management Domain are located within DNG. R5_101 is in close proximity to an area of Rough-barked Apple Woodland and Yellow Box Woodland, while R5_100 is bordered by an ephemeral vegetated creek line. The results of fauna species diversity within regeneration area 5 are shown in Table 27.

There were two bird species listed as vulnerable under the BC Act recorded within regeneration area 5, Brown Treecreeper and Speckled Warbler, both of which were recorded in R5_100.

Table 27: Fauna species diversity within Regeneration Area 5 across 2019 monitoring

Season	R5_100	R5_101
Summer	16	7
Winter	20	8
Spring	19	15
Combined bird diversity	36	21

3.3.9 Rehabilitation Areas

Total bird species diversity across the rehabilitation areas was 23 bird species. Bird diversity across Winter and Spring 2019 has increased at both rehabilitation area sites, with 2019 recording the highest or equal highest bird diversity across all monitoring years (Figure 13).

Sites R6 and R9 are surrounded by active mine operations which presents limitations to landscape connectivity and fauna dispersal. Both sites have a dense groundcover dominated by exotic pasture species. These sites are to be rehabilitated to a woodland community, with scattered eucalypt seedlings and saplings being present. The results of fauna species diversity within rehabilitation areas are shown in Table 28**.**

There was one bird species listed as vulnerable under the BC Act recorded within the rehabilitation areas being a Speckled Warbler, recorded at site R9.

Table 28: Fauna species diversity within rehabilitation areas across 2019 monitoring

Season		R6	R9
Summer	Birds	5	7
Winter	Birds	6	10
Spring	Birds	8	8
Total		11	18

3.3.10 Limitations

Similar to 2018, the 2019 monitoring program took place during a period of ongoing drought in the region. The months leading up to and during Spring 2019 monitoring experienced below average rainfall. Drier conditions may have decreased foraging resource availability for birds, and therefore abundances could be potentially lower, with some species moving away to areas with more suitable conditions. Dry condition may also negatively impact on habitat quality and availability within streams and pools. A decline in available surface water could be expected to significantly impact amphibian activity and breeding cycles.

4. Recommendations and conclusion

4.1 Vegetation

Vegetation monitoring was undertaken within all Management Domains and selected reference sites prescribed by the WCPL BMP during 2019. A total of 20 sites across Autumn and Spring did not the meet the Year 1-5 IPT, triggering the Native Vegetation and Habitat Complexity (BioMetric) TARP (WCPL 2017). This includes all regeneration and rehabilitation sites. Overall the Site Value scores for most sites have declined since 2018, most likely due to lower than average rainfall. Drought conditions and below average rainfall have been experienced across the region since 2017. Sites D_101 and R10 show decreasing site value scores overtime and are not tracking towards benchmark values, while other sites including R5_101, R8, R9, and R5_100 show a positive trend towards there IPT.

Monitoring in 2019 across the BOAs, ECAs, and regeneration areas represents Year 3 for Autumn and Year 4 for Spring which falls within the 1-5 year IPT. These years are the establishment period where intensive management activities to improve ecological attributes are completed. Rehabilitation areas are temporarily being assessed as Year 0, until sites have been reworked to their target BVT.

Consistent with previous monitoring, NOC, EC and NTH are the site attributes that are continuing to perform well across the management domains. This includes the regeneration and rehabilitation areas, however the year 1-5 IPT for NTH is zero, explaining the unusually high performance of this site attribute. OR and FL are consistently not meeting targets as these are attributes that naturally progress slowly through time. It is considered these sites require either the passage of time for natural development or management intervention in order to achieve this site attribute target.

The results collected at reference sites allow a comparison with vegetation sites within the various Management Domains. The BMP suggests that baseline data collected from Year 0 monitoring at the reference sites will be used to develop more relevant, locally based benchmark values against which future monitoring data would be analysed.

4.2 Landscape stability

The LOI data captured during the 2015 – 2017 monitoring, demonstrated consistently high scores, although 2018 and 2019 data has demonstrated a decrease in LOI with three sites below 0.8 indicating extensive areas of bare soil. All sites except for R11 and R4_100 meet the stability completion criteria, this indicates that levels of erosion within the majority of sites are low and is consistent with previous monitoring seasons. Infiltration and nutrient cycling within all management domains did not meet the completion criteria, which is consistent with previous results. Ongoing LFA monitoring will enable identification of long-term trends.

4.3 Fauna

The varying weather conditions between monitoring years highlights the need for continued monitoring at all sites to increase the dataset and enable identification of long-term trends. Following recommendations from last year, Winter bird surveys did not commence in 2019 until flowering of key winter-flowering species was confirmed, in order to increase the likelihood of recording specialist feeders such as Regent Honeyeater and Swift Parrot. In addition to this, it is recommended that when

monitoring at sites where flowering is occurring, Regent Honeyeater call-playback methods be utilised, to further increase the likelihood of recording this species. This can be utilised for Winter flowering species, such as *Eucalyptus albens*, and Spring flowering species including *Eucalyptus melliodora* (Yellow Box) which has been utilised by this species as a secondary food source.

In accordance with 2018 recommendations, artificial fauna habitat, including tin, tiles and logs were placed at selected fauna monitoring sites in 2019 to provide shelter for reptiles and amphibians with the aim to improve detection rates. This fauna habitat will be monitored in subsequent years.

Some of the established fauna monitoring sites where artificial fauna habitats have been established (such as A_100) are located in open areas, isolated from surrounding vegetation. Vegetation corridors could be considered to connect this habitat to surrounding vegetation, in order to make the artificial habitat more accessible for animals. Alternatively, extra fauna habitat such as LWD should be placed at these sites to link monitoring sites with surrounding vegetation.

4.4 General recommendations

A review of the monitoring results and recommendations to inform future monitoring and assist progression toward Completion Criteria is presented below in Table 29.

Table 29: Review of monitoring results and recommendations

Interim Performance Target	Comment from results	Recommendations
Vegetation		
IPTs are listed in the BMP for Western Slopes Dry Sclerophyll Forest and Western Slopes Grassy Woodlands based on vegetation condition. Biometric site attribute scores for the Management Domain monitoring sites (ECAs, BOAs, regeneration and rehabilitation areas) were compared to the IPTs whilst reference sites were compared to Benchmark Targets.	Management Domain sites surveyed during Spring 2019 monitoring demonstrated achievement for some IPTs. OR and FL are the two attributes that are consistently falling, failing to meet the benchmark set at many of the sites, and more focus needs to be placed on these two site attributes.	Targeted planting of native overstorey and mid storey species is recommended across all Management domains but particularly rehabilitation and regeneration areas to accelerate the establishment of the mid and upper strata. Planting activities should be completed after substantial rainfall to increase the likelihood of success. These recommendations are in line with short term biodiversity management strategies outlined in the BMP. Placement of Large Woody debris (at least 10 m) is recommended across all management domains, with particular emphasis on the sites not meeting the FL attribute. Establishment and ongoing monitoring of the reference sites to inform the development of more relevant, site-specific benchmarks. Refer to the TARP for specific actions in the event that the SVS is below the IPT. Continue implementation of nest boxes into areas not meeting NTH IPT, which will provide habitat for hollow dependant fauna.
The management of Priority weeds is listed as a priority in the BMP in accordance with the legal responsibility of WCPL under the (now repealed) *Noxious Weeds Act 1993*.	Declared weed species were recorded within the ECA, regeneration and rehabilitation Management Domains	Ongoing weed management is recommended across all Management Domains with a focus on the occurrences of Priority weeds. Targeted weed management is recommended. Priority weed locations have been noted and their presence should be reviewed during future monitoring periods.
Landscape Function Analysis (LFA)		
Completion criteria for SSA indices (Slope Stability, Soil Infiltration and Nutrient Cycling) are listed in the BMP as a minimum score of 50. The BMP also anticipates a minimal annual increase by 5% for these scores.	LOI values indicate stable, functioning landforms, was recorded at most sites. Overall there has been a decrease in LOI indicating increased amounts of bare soil at many sites. Stability was above completion criteria for most sites. Soil Infiltration and Nutrient Cycling scores were more variable and below	Management measures to be implemented as recommended in the BMP would be expected to improve LFA monitoring results over time. Annual improvement of less than 5% for any of the SSA indices triggers the requirement for further investigation. WCPL should review past management measures in these areas and consult the BMP recommended management actions going forward.

Interim Performance Target	Comment from results	Recommendations
	completion criteria at all sites except for reference sites. Many Soil Infiltration and Nutrient Cycling scores reduced instead of recording the anticipated annual improvement of 5%	Continued monitoring of sites to provide longer term data and determine the effectiveness of management actions. Planting perennial vegetation within sites where nutrient cycling and infiltration values are low. Planting activities should be completed after substantial rainfall to increase the likelihood of success. Refer to the TARP for specific actions in the event that the sites do not meet either the completion criteria or the minimal annual increase by five.
Fauna		
Landforms and vegetation structure within WCPL Management Domains are inhabited or frequented by local fauna.	A broad variety of species were recorded in monitoring sites across the various Management Domains. These results demonstrate that the condition of landforms, vegetation structure and other habitat features at the monitoring sites, including the surrounding environment, were a key factor in determining species numbers and diversity.	Due to the ease of surveying birds and microbats, they are regularly a focus of monitoring surveys and are analysed as an indicator of biodiversity. Comparison of bird and microbat assemblages can be undertaken and tracking of trends over time can indicate sites providing improved habitat. Artificial habitat, including tiles and tin, was placed as selected fauna monitoring sites in 2019. These should be actively monitored during each survey period, by checking underneath tiles and tin to determine if species are utilising habitat. Some fauna trapping sites, such as A_100, are located in the middle of paddocks and are isolated from nearby vegetation, and therefore trapping results at these sites is consistently low. Vegetation and/or LWD corridors leading to these sites and beyond will improve connectivity and allow species to begin to utilise these sites. Alternatively, relocation of sites to vegetated areas could be considered.
Introduced feral and pest species control is essential to environmental management works with targeted programs implemented.	There was only one introduced species (Common Starling) recorded during fauna monitoring in Spring 2019. Targeted monitoring of introduced feral and pest species would be necessary to determine abundance and activity levels.	Ongoing management of introduced species is recommended. Management methods are to be implemented as per the BMP (including poison baiting of predators and ripping rabbit warrens). Ongoing control of introduced predators will reduce pressure on native species.

5. References

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Appendix A – Discontinued sites

Management Domain	Site	Type	Season/year site was last monitored	Reason
Regeneration Area	R1_100	Biometric and LFA	Autumn 2017	Discontinued due to mine expansion
	R1_101	Biometric	Spring 2017	Discontinued due to mine expansion
	R3_100	Biometric	Autumn 2017	Discontinued due to mine expansion
	R6_101	Biometric and LFA	Autumn 2017	Discontinued due to mine expansion
	R7_100	Biometric	Autumn 2017	Discontinued due to mine expansion
	R7_101	Biometric	Spring 2017	Discontinued due to mine expansion
	R8_100	Biometric	Autumn 2017	Discontinued due to mine expansion
Rehabilitation	R1_C	Biometric	Spring 2016	Discontinued due to the end of the cattle trial.
	R2_C	Biometric	Spring 2016	Discontinued due to the end of the cattle trial.
	R3_C	Biometric	Spring 2017	Discontinued due to the end of the cattle trial.
	R5_C	Biometric and LFA	Spring 2017	Discontinued due to the end of the cattle trial.
ECA-C	C_100	Biometric	Spring 2015	Discontinued as there was no access to the site
BOA-D	D_100	Biometric	Spring 2018	Transferred to National Parks Estate and is under the management of NPWS.
	D_101	Biometric	Autumn 2019	Transferred to National Parks Estate and is under the management of NPWS.
	D_102	Biometric	Spring 2018	Transferred to National Parks Estate and is under the management of NPWS.
	D_103	Biometric	Autumn 2019	Transferred to National Parks Estate and is under the management of NPWS.
BOA-E	E_100	Biometric	Autumn 2019	Transferred to National Parks Estate and is under the management of NPWS.
	E_101	Biometric	Spring 2018	Transferred to National Parks Estate and is under the management of NPWS.
	E_102	Biometric	Spring 2018	Transferred to National Parks Estate and is under the management of NPWS.
	E_104	Biometric	Spring 2018	Transferred to National Parks Estate and is under the management of NPWS.
	E_105	Biometric and LFA	Autumn 2019	Transferred to National Parks Estate and is under the management of NPWS.
	E_106	Biometric	Autumn 2019	Transferred to National Parks Estate and is under the management of NPWS.
Reference sites	Ref_1	Biometric and LFA	Spring 2018	Discontinued as the site does not meet the required BVT
	Ref_2	Biometric and LFA	Spring 2018	Discontinued as the site does not meet the required BVT
	Ref_3	Biometric and LFA	Spring 2018	Discontinued as the site does not meet the required BVT
	Ref_4	Biometric and LFA	Spring 2018	Discontinued as the site does not meet the required BVT

Management Domain	Site	Type	Season/year site was last monitored	Reason
	Ref_5	Biometric and LFA	Spring 2018	Discontinued as the site does not meet the required BVT
	Ref_6	Biometric and LFA	Spring 2018	Discontinued as the site does not meet the required BVT
	Ref_7	Biometric and LFA	Spring 2018	Discontinued as the site does not meet the required BVT
	Ref_9	Biometric and LFA	Spring 2018	Discontinued as the site does not meet the required BVT
	Ref_10	Biometric and LFA	Spring 2018	Discontinued as the site does not meet the required BVT
	Ref_11	Biometric and LFA	Spring 2018	Discontinued as the site does not meet the required BVT
	Ref_12	Biometric and LFA	Spring 2018	Discontinued as the site does not meet the required BVT
	Ref_13	Biometric and LFA	Autumn 2018	Discontinued as the site does not meet the required BVT
	Ref_14	Biometric and LFA	Autumn 2019	Discontinued as the site does not meet the required BVT
	Ref_15	Biometric and LFA	Autumn 2018	Discontinued as the site does not meet the required BVT
	Ref_16	Biometric and LFA	Autumn 2018	Discontinued as the site does not meet the required BVT
	Ref_17	Biometric and LFA	Autumn 2019	Discontinued as the site does not meet the required BVT
	Ref_18	Biometric and LFA	Autumn 2018	Discontinued as the site does not meet the required BVT
	Ref_19	Biometric and LFA	Autumn 2018	Discontinued as the site does not meet the required BVT
	Ref_20	Biometric and LFA	Autumn 2018	Discontinued as the site does not meet the required BVT
	Ref_21	Biometric and LFA	Autumn 2018	Discontinued as the site does not meet the required BVT
	Ref_22	Biometric and LFA	Autumn 2018	Discontinued as the site does not meet the required BVT
	Ref_25	Biometric and LFA	Autumn 2018	Discontinued as the site does not meet the required BVT
	Ref_26	Biometric and LFA	Autumn 2018	Discontinued as the site does not meet the required BVT

Appendix B – Weather conditions

Table A – 1: 2019 Monthly mean and historical average weather conditions

Month	2019			Historical Averages		
	Min Temp (°C)	Max Temp (°C)	Total Rainfall (mm)	Min Temp (°C)	Max Temp (°C)	Rainfall Mean (mm)
January	18.9	41.4	54.8	16.9	31.3	70.5
February	11.2	38.3	7.4	16.4	30.0	60.9
March	7.5	34.3	108.8	13.8	27.5	55.0
April	3.1	30.6	0	9.9	23.6	43.7
May	1.2	24.5	17.6	6.3	19.2	44.7
June	-4.4	22.9	10.6	3.6	15.5	50.4
July	-2.1	22	2.6	2.6	14.9	48.5
August	-4.5	25.2	10.2	3.3	16.6	45.5
September	-1.1	30	23	6.0	19.9	46.9
October	4	34.6	5.6	9.3	23.8	55.2
November	6.8	37.1	22	12.3	26.8	59.7
December	10.4	42.5	3	15.0	29.9	66.9

Source: WCPL (2019 data); Bureau of Meteorology, 2019 (Historical averages) Temperature data from Gulgong Post Office weather station number 62013. Rainfall from Wollar (Barrigan St) Weather station number 62032.

Table A – 2: Weather conditions during 2019 Biodiversity Monitoring Program

Date	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)	Average Wind Speed (km/hr)
Summer bird monitoring				
19/2/19	22.1	38.3	0	1
20/2/19	21.7	33.9	0	3.1
21/2/19	21.3	26	0	4.7
22/2/19	19	24.8	0	5.3
23/2/19	17.8	25.8	0	4.3
24/2/19	17.9	24	0	5.5
25/2/19	16.8	25.8	0	4.3
26/2/19	12.8	30.9	0	1.2
27/2/19	12.5	28.5	0	3.1
28/2/19	18.2	27.8	0	3.3
Autumn monitoring				
12/3/19	18.4	32.4	0	1.7

Date	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)	Average Wind Speed (km/hr)
13/3/19	15.4	28.5	0	3.2
14/3/19	20.4	32.3	0	0.3
15/3/19	13.8	27.5	0	2.7
16/3/19	16.5	25.5	0	3.6
17/3/19	17.5	23.3	28.8	0.4
18/3/19	16	24.6	1.6	1.9
Winter bird monitoring				
17/6/19	16.3	10.1	0	0.7
18/6/19	15.4	11.5	0	1.2
19/6/19	15.3	6.4	0	0.7
20/6/19	15.6	5.3	0	0.4
21/6/19	13.7	5	0	0.4
6/8/19	-3.5	19.9	0	1.2
7/8/19	-2.6	21.2	0	1.4
8/8/19	1.6	19.2	0	3.3
9/8/19	7.9	12.9	0	5.6
10/8/19	1.2	9.7	2.4	4.6
11/8/19	2.6	8.9	5.6	5.2
12/8/19	1.2	15	0	1.9
13/8/19	-1.8	16.5	0.2	1.2
Spring monitoring				
17/9/19	13.7	26.4	0	0.6
18/9/19	10.4	23	3.6	2.5
19/9/19	4.5	19.5	0	2.3
20/9/19	1.6	20.5	0	0.9
21/9/19	2.6	22.5	0	0.3
22/9/19	5.6	23.4	0	0.5
23/9/19	3.4	23.9	0	1.9
24/9/19	5	23.2	0	2
25/9/19	5	23.2	0	1.6
26/9/19	5.1	22.3	0	2.3
27/9/19	11.6	23	0	2.7
28/9/19	6.4	26.2	0	0.8
29/9/19	6.9	28.6	0	0.8
30/9/19	8.2	30.7	0	2.1
1/10/19	14.9	23.4	0	2.8

Date	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)	Average Wind Speed (km/hr)
2/10/19	13	34.6	0	1.2
3/10/19	13.3	33.6	0	2.4
4/10/19	9.8	21.5	0	3.5
5/10/19	4	22.3	0	0.7
6/10/19	5.8	21.4	0	1.9
7/10/19	10.4	19.8	5.2	2.2
8/10/19	10.7	15.8	0.2	3.6
9/10/19	6.8	21	0	2.1
10/10/19	11.9	27.6	0	1
11/10/19	10.2	31.5	0	0.8
12/10/19	9.9	31.7	0	1
13/10/19	13.3	24.2	0.2	3.1
14/10/19	6	24.4	0	2.3
15/10/19	4	26.3	0	2.9
16/10/19	6.2	24.2	0	1
17/10/19	5.4	26.8	0	0.9
18/10/19	9.3	29.7	0	0.9
19/10/19	9.4	30.9	0	0.8
20/10/19	10.6	32.3	0	1
21/10/19	10.6	33.7	0	2.5
22/10/19	15.4	27.1	0	4.6
23/10/19	5.7	25.3	0	1.2
24/10/19	6.7	27.7	0	1.9
25/10/19	11.5	30.2	0	0.1
26/10/19	12.7	30.6	0	1.8
27/10/19	12.7	31.9	0	0.7
28/10/19	12.8	33	0	0.3
29/10/19	14.2	31.7	0	1.6
30/10/19	17.1	27.1	20.6	2.2
31/10/19	14.8	24.2	0.2	3.1
1/11/19	11.8	21.2	0	3
2/11/19	6.8	26.5	0	2.5
3/11/19	14.7	27.7	0	5.1
4/11/19	11.8	26.5	0	4.2
5/11/19	10.4	19.4	0	4
6/11/19	11.2	24.7	0	3.4

Date	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)	Average Wind Speed (km/hr)
7/11/19	8.4	28.1	0	0.8
8/11/19	8.1	33.3	0	4.1
9/11/19	13.3	23.3	0	3.5
10/11/19	8.7	26.6	0	2.1
11/11/19	10	29.5	0	3
12/11/19	10.9	29.2	0	1.2
13/11/19	12.4	27.8	0	0.6
14/11/19	17.9	25.7	0	0.7
15/11/19	10.7	34.4	0	1.8
16/11/19	16.3	31.2	0	2.7
17/11/19	16.3	37.1	0	1
18/11/19	19	36.7	0	1.3
19/11/19	13.7	26.4	0	0.6
20/11/19	10.4	23	3.6	2.5
21/11/19	4.5	19.5	0	2.3
22/11/19	1.6	20.5	0	0.9

Source: WCPL

Table A – 3: Monthly Rainfall from 2013 – 2019 (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2013	73.6	54.2	61.4	12.2	17.4	77.9	20.8	6.6	33.0	8.8	78.6	27.6	472.1
2014	15.6	60.0	112.6	62.8	13.8	29.8	28.6	28.8	14.6	15.4	24.4	126.7	533.1
2015	127.6	11.6	9.4	108.4	42.8	42.8	38.0	53.8	7.8	61.0	59.0	118.4	680.6
2016	152.1	7.2	23.5	14.8	66.8	104.2	101.1	40.9	198.7	86.6	51.9	90.6	938.4
2017	27.8	34.2	146	23	32.4	10.4	5.8	25.2	3	28.4	92.6	102.6	531.4
2018	24.4	77	24.6	42.2	12.4	21.6	1.2	43.8	39.6	56.8	47.4	91.2	482.2
2019	54.8	7.4	108.8	0	17.6	10.6	2.6	10.2	23	5.6	22	3	265.6
Historical Mean	**70.5**	**60.9**	**55.0**	**43.7**	**44.7**	**50.4**	**48.5**	**45.5**	**46.9**	**55.2**	**59.7**	**66.9**	647.7

Source: WCPL and Bureau of Meteorology, 2017 (Historical averages) Wollar (Barrigan St) Weather station number: 62032.

Appendix C – 2019 Biodiversity monitoring sites

Table B – 1: Autumn 2019 Vegetation Monitoring sites

Domain	Site	Management Domain	Condition	Keith Vegetation Class	Vegetation Community	Easting	Northing
BOA D + E	D_101	BOA-D	Native vegetation	WSDSF	Narrow-leaved Ironbark Woodland	784318	6427419
	D_103	BOA-D	Native vegetation	WSDSF	Mugga Ironbark Woodland	784084	6427171
	E_100	BOA-E	Native vegetation	WSDSF	Narrow-leaved Ironbark – Brown Bloodwood – Dwyer's Red Gum Woodland	778311	6419426
	E_105	BOA-E	Regeneration	WSGW	White Box Grassy Woodland (regenerating)	779016	6419982
	E_106	BOA-E	Native vegetation	WSGW	White Box Grassy Woodland (DNG)	778855	6420402
BOA 1 – 5	BOA1_100	BOA_1	Native Vegetation	WSDSF	White Box Shrubby Woodland	766944	6414592
	BOA2_100	BOA_2	Native Vegetation	WSDSF	White Box Shrubby Woodland	769159	6413073
ECA	A_102	ECA-A	Regeneration	WSGW	Box-Gum Grassy Woodland on Valley Floors (DNG)	772917	6417079
	A_103	ECA-A	Native vegetation	WSGW	Blakely's Red Gum Woodland	773142	6417621
	B_103	ECA-B	Native vegetation	WSDSF	Grey Gum – Narrow-leaved Stringybark Forest	771079	6420160
	B_106	ECA-B	Regeneration	WSGW	Yellow Box Woodland (DNG)	771570	6420003
	C_101	ECA-C	Regeneration	WSDSF	White Box Shrubby Woodland (DNG)	768365	6416938
	R5_100	Regeneration Area 5	Regeneration	WSGW	Rough-barked Apple Woodland (DNG)	769194	6421424
	R9_101	Regeneration Area 9	Regeneration	WSGW	Rough-barked Apple Woodland (DNG)	768829	6422231
Rehabilitation	R6	Rehabilitation	Rehabilitation	WSDSF	NA	769566	6419516
	R9	Rehabilitation	Rehabilitation	WSDSF	NA	769120	6418969
	Ref_14	Goulburn River NP	Native vegetation	WSDSF	Ironbark Bloodwood Red Gum Woodland	782174	6421967
	Ref_17	Turill SCA	Native vegetation	WSGW	Blakely's Red Gum Woodland	776767	6452950
	Ref_23	Goulburn River NP	Native vegetation	WSGW	Yellow Box Grassy Woodland	769183	6422270

Domain	Site	Management Domain	Condition	Keith Vegetation Class	Vegetation Community	Easting	Northing
	Ref_24	BOA-E	Native vegetation	WSGW	White Box Shrubby Woodland	779295	6419440

Table B – 2: Spring 2019 vegetation monitoring sites

Domain	Site	Management Domain/Location	Condition	Keith Vegetation Class	Vegetation Community	Easting	Northing
ECA	A_100	ECA-A	Regeneration	WSGW	DNG – other native (non-EEC)	771861	6416276
	A_104	ECA-A	Native Vegetation	WSGW	Narrow-leaved Ironbark Forest	773695	6416293
	B_100	ECA-B	Native Vegetation	WSGW	Sandstone Ranges Shrubby Woodland	770111	6420997
	B_101	ECA-B	Regeneration	WSGW	DNG – other native (non-EEC)	770542	6420592
	B_105	ECA-B	Regeneration	WSDSF	DNG – other native (non-EEC)	773141	6420468
	C_102	ECA-C	Native Vegetation	WSGW	Shrubby White Box Woodland	768940	6417281
Regeneration Area	R2_101	Regeneration Area 2	Regeneration	WSGW	DNG – other native (non-EEC)	772639	6418355
	R4_100	Regeneration Area 4	Regeneration	WSGW	DNG – other native (non-EEC)	770347	6420268
	R5_101	Regeneration Area 5	Regeneration	WSDSF	DNG – other native (non-EEC)	769500	6421595
	R9_100	Regeneration Area 9	Regeneration	WSDSF	DNG – other native (non-EEC)	768975	6422067
Rehabilitation Area	R8	Rehabilitation Area	Rehabilitation – Grassland	WSGW	N/A	770231	6418596
	R10	Rehabilitation Area	Rehabilitation – Grassland	WSGW	N/A	768433	6419301
	R11	Rehabilitation Area	Rehabilitation – Grassland	WSGW	N/A	768896	6419664

Domain	Site	Management Domain/Location	Condition	Keith Vegetation Class	Vegetation Community	Easting	Northing
	Ref_8	Goulburn River NP	Native vegetation	WSGW	White Box Shrubby Woodland	781932	6414688

Table B – 3: LFA monitoring sites

Site	Management Domain	Easting	Northing	Zone	Type
A_100	ECA-A	771861	6416276	55H	BioMetric and LFA
B_106	ECA-B	771571	6420001	55H	LFA
R10	Rehabilitation Area	768433	6419301	55H	BioMetric and LFA
R11	Rehabilitation Area	768896	6419664	55H	BioMetric and LFA
R13	Rehabilitation Area	770872	6418901	55H	LFA
R4_100	Regeneration Area 4	770347	6420268	55H	BioMetric and LFA
R6	Rehabilitation Area	769562	6419517	55H	LFA
R8	Rehabilitation Area	770231	6418596	55H	BioMetric and LFA
R9	Rehabilitation Area	769118	6418973	55H	LFA
Ref_8	Goulburn River NP	781932	6414688	55H	BioMetric and LFA

Table B – 4: Fauna monitoring sites

Area	Site ID	Coordinates		Management Zone	Vegetation Class	Survey		
		Easting	Northing			Fauna	Bats	Birds only
ECA-A	A_100	771861	6416276	Regeneration (poor resilience)	Western Slopes Grassy Woodland	Y		
	A_102	772926	6417078	Regeneration (moderate resilience)	Western Slopes Grassy Woodland	Y		
	A_104	773695	6416293	Native vegetation (good resilience)	Western Slopes Grassy Woodland	Y	Y	
BOA-D	D_100	784857	6427722	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest	Y		
	D_101	784306	6427422	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest	Y		
	D_103	784083	6427173	Regeneration (moderate resilience)	Western Slopes Dry Sclerophyll Forest	Y	Y	
BOA-E	E_100	778299	6419408	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest	Y		
	E_104	779148	6419734	Native vegetation (good resilience)	Western Slopes Grassy Woodland	Y	Y	
	E_106	778854	6420399	Native vegetation (good resilience)	Western Slopes Grassy Woodland	Y		
BOA-1	BOA1_100	766963	6414300	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest	Y	Y	
	BOA1_101	767441	6414516	Regeneration (moderate resilience)	Western Slopes Grassy Woodland			Y
BOA-2	BOA2_100	769440	6413937	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest	Y	Y	
	BOA2_101	769050	6413570	Native vegetation (good resilience)	Western Slopes Grassy Woodland			Y
BOA-3	BOA3_100	784649	6421025	Native vegetation (good resilience)	Western Slopes Grassy Woodland	Y	Y	
	BOA3_101	784714	6422246	Native vegetation (good resilience)	Western Slopes Grassy Woodland			Y

Area	Site ID	Coordinates		Management Zone	Vegetation Class	Survey		
		Easting	Northing			Fauna	Bats	Birds only
	BOA3_102	784258	6421909	Native vegetation (good resilience)	Dry Rainforest	Y		
BOA-4	BOA4_100	782475	6424100	Native vegetation (good resilience)	Western Slopes Grassy Woodland			Y
	BOA4_101	782527	6423888	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest	Y	Y	
BOA-5	BOA5_100	784073	6417976	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest	Y	Y	
	BOA5_101	783192	6419415	Native vegetation (good resilience)	Western Slopes Grassy Woodland	Y		
	BOA5_102	784493	6419150	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest			Y
ECA-B	B_100	770111	6420997	Native vegetation (good resilience)	Western Slopes Grassy Woodland	Y		
	B_101	770542	6420592	Regeneration (moderate resilience)	Western Slopes Grassy Woodland	Y	Y	
	B_103	771072	6420157	Native vegetation (good resilience)	Western Slopes Dry Sclerophyll Forest	Y		
	B_105	773141	6420468	Regeneration (moderate resilience)	Western Slopes Dry Sclerophyll Forest			Y
ECA-C	C_101	768377	6416929	Regeneration (moderate resilience)	Western Slopes Dry Sclerophyll Forest	Y		
	C_102	768940	6417281	Native vegetation (good resilience)	Western Slopes Grassy Woodland	Y	Y	
Regeneration Area 4	R4_100	770347	6420268	Regeneration (no resilience)	Western Slopes Grassy Woodland			Y
Regeneration Area 5	R5_100	769191	6421422	Regeneration (moderate resilience)	Western Slopes Grassy Woodland			Y
	R5_101	769500	6421595	Regeneration (moderate resilience)	Western Slopes Dry Sclerophyll Forest			Y
Regeneration Area 6	R6_101	767406	6420303	Regeneration (no resilience)	Western Slopes Grassy Woodland			

Area	Site ID	Coordinates		Management Zone	Vegetation Class	Survey		
		Easting	Northing			Fauna	Bats	Birds only
Rehabilitation	R6	769562	6419517	Rehabilitation - Woodland	Western Slopes Dry Sclerophyll Forest	Y		
	R9	769118	6418973	Rehabilitation - Woodland	Western Slopes Dry Sclerophyll Forest	Y		
Reference sites	Ref_2	224153	6424016	Goulburn River NP	Western Slopes Dry Sclerophyll Forest	Y	Y	
	Ref_3	217853	6424354	Goulburn River NP	Western Slopes Grassy Woodland	Y	Y	
	Ref_5	779353	6419939	WCPL Offset Area	Western Slopes Grassy Woodland	Y	Y	
	Ref_8	781933	6414689	Goulburn River NP	Western Slopes Grassy Woodland	Y	Y	
	Ref_10	220576	6428690	Goulburn River NP	Western Slopes Grassy Woodland	Y	Y	
	Ref_14	782174	6421967	Goulburn River NP	Western Slopes Grassy Woodland	Y	Y	

Appendix D - Ultrasonic Analysis Report

Ultrasonic Analysis Report – Wilpinjong Coal Pty Ltd (WCPL) offset sites Spring monitoring 2019.

The survey involved a total effort of sixteen (16) recording or survey nights between 16 October and 20 November 2019.

PROJECT BACKGROUND AND SITE DESCRIPTION

Report completed 21 January 2020.

Eco Logical Australia Pty Ltd (ELA) was engaged by WCPL to analyse ultrasonic microchiropteran bat call data collected from a number of sites associated with their offset sites. This data forms part of an ongoing annual biodiversity monitoring program.

This report outlines the methodology used and results of the data analysis.

METHODS

Five (5) Song Meter (SM) (Wildlife Acoustics) and Anabat Swift (AS) (Titley Electronics) ultrasonic detectors were set at eight locations between the 16 October and 20 November 2019 within the WCPL study area. Table 1 provides an overview of when the recordings were undertaken, a description of survey effort, and the identification number of the detector used to conduct each survey. Each detector was set to record ultrasonic call data across the entire night (e.g. dusk to dawn).

Table 1: The Wilpinjong survey site numbers, survey dates, survey effort and detector identification numbers

Offset Area	Site name and number	Survey dates	Survey effort	Detector identification number
BOA	BOA1-100	16 – 18 October 2019	Two survey nights	ABS3
	BOA2-101	16 – 18 October 2019	Two survey nights	ABS2
	BOA3-100	21 – 23 October 2019	Two survey nights	ABS4
	BOA4-101	11 – 13 November 2019	Two survey nights	SM2-1
	BOA5-101	21 – 23 October 2019	Two survey nights	ABS3
ECA-A	A_104	16 – 18 October 2019	Two survey nights	AB3
ECA-B	B_101	11 – 13 November 2019	Two survey nights	AB3
ECA-C	C_1102	18 – 20 November 2019	Two survey nights	ABS2

DATA ANALYSIS

The ultrasonic call data was recorded passively on either a Song Meter (SM) (Wildlife Acoustics) or Anabat Swift recorder (Titley Electronics). Files recorded on the Anabat Swifts were recorded in WAV

sound files. These WAV files were converted on a computer using Anabat Insight to a zero crossing (ZC) format for analyses (Titley Electronics). All of the calls recorded on the SM were in ZC format.

The bat calls were then analysed by ELA ecologist Rodney Armistead using the program AnalookW (Version 4.4a 17 September 2018, written by Chris Corben, www.hoarybat.com). Rodney has over five years of experience in the identification of ultrasonic call recordings. Call identifications are made using regional based guides to the echolocation calls of microbats in New South Wales (Pennay et al 2004); and south-east Queensland and north-east New South Wales (Reinhold et al 2001) and the accompanying reference library of over 200 calls from Sydney Basin, NSW (which is available at http://www.forest.nsw.gov.au/research/bats/default.asp). Species identification was guided by considering probability of occurrence based upon the general distribution information that is provided in Churchill (2008); Pennay et al. (2011), Van Dyck and Strahan (2008) and Van Dyck et al. (2013). This report and a sample of the calls were reviewed by Alicia Scanlon also from ELA. Alicia has over 13 years of experience in the identification of ultrasonic call recordings.

Bat calls are analysed using species-specific call profile parameters including call shape, characteristic frequency, initial slope and time between pulses (Reinhold et al. 2001). To ensure reliable and accurate results the following protocols (adapted from Lloyd et al 2006) are followed:

- Search phase calls are used in the analysis, rather than cruise phase calls or feeding buzzes (McKenzie et al 2002). Cruise phase or feeding calls are labelled as being unidentifiable.
- Recorded calls containing less than three pulses are not analysed and these sequences are labelled as unidentifiable, being too short to confidently determine the identity of the species making the call (Law et al 1999)
- For those calls that are useful to identify the species making the call, two categories of confidence are used (Mills et al1996):
    - Definitely present – the quality and structure of the call profile is such that the identity of the bat species making the calls is not in doubt
    - Potentially present – the quality and structure of the call profile is such that there is some / low probability of confusion with species that produce similar calls profiles
- Calls made by bats that cannot be used for identification purposes such as social calls, short and low-quality calls, cruise and approach phase calls were labelled as unidentifiable.
- Sequences labelled as unidentifiable are of inferior quality and therefore cannot be used to identify any microbat species, they can, however, be used as an indicator of microbat activity at the site.
- *Nyctophilus* spp. (Long-eared bats) are difficult to identify or separate confidently to species level based upon their recorded calls. Therefore, we have made no attempt to identify any recorded *Nyctophilus* spp. calls recorded during this survey to species level (Pennay et al 2004). There are three potential *Nyctophilus* species that could occur in the study area. Two non-threatened species, including *N. geoffroyi* (Lesser Long-eared Bat) and *N. gouldii* (Gould's Long-eared Bat). Both of these species are relatively common and widely distributed across NSW. However, the third species, *N. corbeni* (Corben's Long-eared Bat) is listed as vulnerable under the NSW *Biodiversity Conservation Act 2016* (BC Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). According to Churchill (2008), Penny et al. (2011) and the Department of the Environment and Energy (DoEE) Species Profile

and Threats Database Corben's Long-eared Bat is likely to occur within the locality of the study area due to the presence of its preferred habitat. Where *Nyctophilus* spp. calls were recorded, we have included this threatened microbat species as potentially being present. To confirm the presence / absence of Corben's Long-eared Bat within the Mod 9 study area, further survey effort would be required that involves the use of mist or harp traps to conduct live capture and release. These surveys would need to fulfil the survey requirements present in Commonwealth of Australia (2010) Survey Guidelines for Australia's threatened bats. For further information regarding the distribution of this species, please refer to the following link, http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=83395.

- The Free-tailed Bats (previously referred to as the genus *Mormopterus*) have recently undergone taxonomic revision (Reardon et al 2014) and published reference calls for this group of species (Pennay et al 2004) are believed to contain errors (Greg Ford pers comm.). This report uses nomenclature for Free-tailed Bat species as referred to in Jackson and Groves (2015). The correlation between nomenclature used in this report and that used in NSW State legislation is presented in **Table 2** below. All Free-tailed Bats in the new genus *Ozimops* potentially occurring within the survey area will therefore be referred to as *Ozimops* species complex. This species grouping includes *Ozimops petersi* (Inland Free-tailed Bat), *O. planiceps* (Southern Free-tailed Bat) and *O. ridei* (Ride's Free-tailed Bat).
- Jackson & Groves (2015) list the Eastern Bent-winged Bat (*Miniopterus schreibersii oceanensis*) under the new name of *M. orianae* (Large Bent-winged Bat). However, we follow the NSW DPIE nomenclature as it applies to the eastern form of the species which occurs in NSW as a distinct sub-species; *M. o. oceanensis* (Large Bentwing Bat) (see https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10534) (NSW Department of Planning, Industry and Environment (formerly the Office Environment and Heritage) 2019).
- Sequences not attributed to microbat echolocation calls (e.g. insect buzzes, wind, train and vehicle movement) were dismissed from the analysis.

Table 2: Correlations between current and previous nomenclature for the Free-tailed bats of NSW

Jackson and Groves 2015	Previously known as	Common Name	BC Act
Austronomus australis	*Tadarida australis*	White-striped Free-tailed Bat	
Micronomus norfolkensis	*Mormopterus norfolkensis*	Eastern Coastal Free-tailed Bat	Vulnerable
Ozimops petersi	*Mormopterus* species 3 (small penis)	Inland Free-tailed Bat	
Ozimops planiceps	*Mormopterus* species 4 (long penis eastern form)	Southern Free-tailed Bat	
Ozimops ridei	*Mormopterus* species 2	Ride's Free-tailed Bat	
Setirostris eleryi	*Mormopterus* species 6	Bristle-faced Free-tailed Bat	Endangered

RESULTS

There were 2,355 call sequences recorded during this survey. Of these, 1,174 (49.85%) were deemed useful, because these call profiles were of sufficient quality and/or length to enable positive

identification of a bat species. The remaining 1,181 (50.15%) call sequences were either too short or were of low quality, thus preventing positive identification of bat species.

There were at least thirteen (13) and up to eighteen (18) species recorded during this survey (**Table 3** and **Table 4**). This includes up to four (4) species that are listed as Vulnerable under the NSW *Biodiversity Conservation Act 2016* (BC Act) (**Table 3** and **Table 4,** and see also **Figure 1** - **Figure 14**). Based on the call profiles, three Vulnerable species under the BC Act were deemed to have been definitely present within the study area;

- ***Chalinolobus dwyeri*** (**Large-eared Pied Bat**)
- ***Miniopterus orianae oceanensis*** (**Large Bentwing Bat**)
- ***Vespadelus troughtoni*** **(Eastern Cave Bat)**

One other threatened species, ***Nyctophilus corbeni*** **(Corben's Long-eared Bat),** which is also listed as Vulnerable under the BC Act could also be present within the study area due to the presence of suitable habitat for this species. However, the defining features of the call profiles assigned to all *Nyctophilus* species overlap and it is impossible to identify calls to species level, as described above.

Consequently, this species was labelled as being potentially present only.

The Large-eared Pied Bat and Corben's Long-eared Bat are also listed as Vulnerable under the EPBC Act. During the 2019 surveys, calls attributed to the Large-eared Pied Bat were recorded at seven of the eight survey sites (General microbat activity was regarded as being very low to moderate across each of the survey sites. Activity levels at BOA1, ECA-A A104 and ECA-C C-102 were considered to be very low with one call recorded every ten minutes, or less, on average throughout the survey period. Sites BOA3 and BOA5 recorded low levels of activity with single calls recorded every five minutes or less, on average throughout the survey period. Moderate microbat activity was recorded at sites ECA_B B101, BOA2 and BOA4 with at least one call being recorded every four minutes on average throughout the survey period.

Table 3). Calls for the Large-eared Pied Bat were not recorded at ECA-A A104 (General microbat activity was regarded as being very low to moderate across each of the survey sites. Activity levels at BOA1, ECA-A A104 and ECA-C C-102 were considered to be very low with one call recorded every ten minutes, or less, on average throughout the survey period. Sites BOA3 and BOA5 recorded low levels of activity with single calls recorded every five minutes or less, on average throughout the survey period. Moderate microbat activity was recorded at sites ECA_B B101, BOA2 and BOA4 with at least one call being recorded every four minutes on average throughout the survey period.

Table 3).

Calls attributed to *Nyctophilus* spp., and therefore potentially Corben's Long-eared Bat, were recorded at three of the eight survey sites, including BOA1, BOA2 and ECA-B B101 (General microbat activity was regarded as being very low to moderate across each of the survey sites. Activity levels at BOA1, ECA-A A104 and ECA-C C-102 were considered to be very low with one call recorded every ten minutes, or less, on average throughout the survey period. Sites BOA3 and BOA5 recorded low levels of activity with single calls recorded every five minutes or less, on average throughout the survey period. Moderate

microbat activity was recorded at sites ECA_B B101, BOA2 and BOA4 with at least one call being recorded every four minutes on average throughout the survey period.

Table 3).

SPECIES DIVERSITY, ACTIVITY AND FORAGING

As stated, at least thirteen (13) and up to eighteen (18) species were recorded during this survey (**General** microbat activity was regarded as being very low to moderate across each of the survey sites. Activity levels at BOA1, ECA-A A104 and ECA-C C-102 were considered to be very low with one call recorded every ten minutes, or less, on average throughout the survey period. Sites BOA3 and BOA5 recorded low levels of activity with single calls recorded every five minutes or less, on average throughout the survey period. Moderate microbat activity was recorded at sites ECA_B B101, BOA2 and BOA4 with at least one call being recorded every four minutes on average throughout the survey period.

Table 3). The species diversity did not vary dramatically across the survey sites (**Table 3** and **Table 4**). The following species were recorded at nearly all of the eight survey sites**; Large Bentwing Bat**, **Large-eared Pied Bat**, *Chalinolobus gouldii* (Gould's Wattle Bat), *C. morio* (Chocolate Wattle Bat), *Rhinolophus megaphyllus* (Eastern Horseshoe Bat), *Vespadelus vulturnus* (Little Forest Bat) and the *Ozimops* species complex (**Table** 4). Whilst, in contrast *Scotorepens greyii* (Little Broad-nosed Bat) was recorded at only two surveys sites (BOA2 and BOA5) (**Table 4**).

The most commonly recorded species within the study area included the threatened Large Bentwing Bat, a complex consisting of three *Vespadelus* species (*V. darlingtoni* (Large Forest Bat)*, V. regulus* (Southern Forest Bat *and* Little Forest Bat) and the *Ozimops* species complex. Collectively, there were 747 (63.63 %) usable calls attributed to Large Bentwing Bat and the *Vespadelus* species complex, either individually or in combination (**Table 5 - Table 12**). As discussed in greater details in **Section 6**, the calls of the Large Bent-winged Bat and several *Vespadelus* species that co-occur can be difficult to separate and calls are assigned mixed species labels when there are no defining characteristics present.

General microbat activity was regarded as being very low to moderate across each of the survey sites. Activity levels at BOA1, ECA-A A104 and ECA-C C-102 were considered to be very low with one call recorded every ten minutes, or less, on average throughout the survey period. Sites BOA3 and BOA5 recorded low levels of activity with single calls recorded every five minutes or less, on average throughout the survey period. Moderate microbat activity was recorded at sites ECA_B B101, BOA2 and BOA4 with at least one call being recorded every four minutes on average throughout the survey period.

Table 3. Microbat species diversity recorded ultrasonically at WPCL survey sites during the 2019 Spring surveys.

Scientific Name	Common Name	Presence
Austronomus australis	White-Striped Free-tailed Bat	D
***Chalinolobus dwyeri*[1]**	**Large-eared Pied Bat**	D
Chalinolobus gouldii	Gould's Wattled Bat	D
Chalinolobus morio	Chocolate Wattled Bat	D
Miniopterus orianae oceanensis*	**Large Bentwing Bat**	D
Nyctophilus geoffroyi	Lesser Long-eared Bat	P

Scientific Name	Common Name	Presence
Nyctophilus gouldii	Gould's Long-eared Bat	P
***Nyctophilus corbeni**[1]*	**Corben's Long-eared Bat**	P
Ozimops petersi	Inland Free-tailed Bat	P
Ozimops planiceps	South-eastern Free-tailed Bat	P
Ozimops ridei	Ride's Free-tailed Bat	P
Rhinolophus megaphyllus	Eastern Horseshoe Bat	D
Scotorepens balstoni	Inland Broad-nosed Bat	D
Scotorepens greyii	Little Broad-nosed Bat	P
Vespadelus darlingtoni	Large Forest Bat	D
Vespadelus regulus	Southern Forest Bat	P
Vespadelus troughtoni*	**Eastern Cave Bat**	D
Vespadelus vulturnus	Little Forest Bat	D

D = Definitely recorded, P = Potentially recorded. *listed as threatened under the BC Act and [1] listed as threatened under the EPBC Act

Table 4. 2019 Spring monitoring microbat species lists by site derived from ultrasonic call results for the WCPL survey sites

Species Name	Common Name	Property							
		BOA					ECA		
		BOA1	BOA2	BOA3	BOA4	BOA5	A_104	B_101	C_102
Austronomus australis	White-striped Free-tailed Bat	-	D	-	-	-	D	D	-
***Chalinolobus dwyeri**[1]*	**Large-eared Pied Bat**	D	D	D	D	D	-	D	D
Chalinolobus gouldii	Gould's Wattled Bat	-	D	D	D	D	D	D	D
Chalinolobus gouldii / *Ozimops* species complex	Gould's Wattled Bat / Free-tailed Bat complex	-	D	D	D	D	D	D	D
Chalinolobus gouldii / *Ozimops* species complex / *Scotorepens balstoni*	Gould's Wattled Bat / Free-tailed Bat complex / Inland Broad-nosed Bat	-	-	-	-	-	D	D	D
Chalinolobus gouldii / *Scotorepens balstoni*	Gould's Wattled Bat / Inland Broad-nosed Bat	D	D	-	D	-	D	D	-
Chalinolobus morio	Chocolate Wattled Bat	D	D	D	D	D	D	D	D
Chalinolobus morio / ***Miniopterus orianae oceanensis**** / *Vespadelus vulturnus*	Chocolate Wattled Bat / **Large Bentwing Bat** / Little Forest Bat	-	-	-	-	-	-	-	-
Chalinolobus morio / ***Vespadelus troughtoni****	Chocolate Wattled Bat **/ Eastern Cave Bat**	-	D	D	-	D	-	D	-
Chalinolobus morio **/ *Vespadelus troughtoni**** / *Vespadelus vulturnus*	Chocolate Wattled Bat / **Eastern Cave Bat** / Little Forest Bat	D	D	D	D	D	D	D	-
Chalinolobus morio / *Vespadelus vulturnus*	Chocolate Wattled Bat / Little Forest Bat	-	-	-	D	-	-	-	-
Miniopterus orianae oceanensis*	**Large Bentwing Bat**	D	D	D	D	D	P	D	D

Species Name	Common Name	Property							
		BOA					ECA		
		BOA1	BOA2	BOA3	BOA4	BOA5	A_104	B_101	C_102
Miniopterus orianae oceanensis* and any or all of the following species, *Vespadelus darlingtoni* / *Vespadelus regulus* / *Vespadelus vulturnus*	**Large Bentwing Bat** and any or all of the following species, Large Forest Bat / Southern Forest Bat / Little Forest Bat	D	D	D	D	D	D	D	D
Nyctophilus spp. In this region *N. geoffroyi*, *N. gouldii* and the threatened ***N. corbeni**[1]* are likely to be present.	In this region Gould's, Lesser, and the threatened **Corben's Long-eared Bat** is likely to be present.	D	D	-	-	D	-	D	-
Ozimops species complex. In this region the *O. petersi*, *O. ridei* and *O. planiceps*.	In this region Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	D	D	D	D	D	D	D	D
Rhinolophus megaphyllus	Eastern Horseshoe Bat	D	D	D	D	D	D	-	-
Scotorepens balstoni	Inland Broad-nosed Bat	-	D	D	-	D	-	D	-
Scotorepens greyii	Little Broad-nosed Bat	-	P	-	-	P	-	-	-
Vespadelus darlingtoni	Large Forest Bat	-	D	-	-	-	-	-	-
Vespadelus darlingtoni / *Vespadelus vulturnus*	Large Forest Bat / Little Forest Bat	-	D	-	-	-	-	D	-
Vespadelus regulus / *Vespadelus vulturnus*	Southern Forest Bat / Little Forest Bat	-	D	D	D	D	-	D	-
Vespadelus troughtoni*	**Eastern Cave Bat**	-	D	-	-	D	-	D	-
Vespadelus troughtoni* / *Vespadelus vulturnus*	**Eastern Cave Bat** / Little Forest Bat	D	D	D	D	D	D	D	-

Species Name	Common Name	Property							
		BOA					ECA		
		BOA1	BOA2	BOA3	BOA4	BOA5	A_104	B_101	C_102
Vespadelus vulturnus	Little Forest Bat	D	D	D	D	D	D	D	D

D = Definitely recorded, P = Potentially recorded. *listed as threatened under the BC Act and [1] listed as threatened under the EPBC Act

SURVEY LIMITATIONS

Calls were only positively identified when the defining characteristics were present and there was no chance of confusion between species with overlapping and/or similar calls. In this survey, there were some call sequences that could not be positively identified to species level. Further, some species recorded in this survey can have call profiles that overlap with other species.

When overlap occurs, species with similar call profiles are assigned to multi species groups of two or three potential species depending on the characteristics displayed in the recorded call sequences.

The species recorded in this survey with overlapping call profiles are described below.

The calls of Gould's Wattled Bat, *Scotorepens balstoni* (Inland Broad-nosed Bat) and the *Ozimops* species complex (Free-tailed Bats) can be difficult to separate. Calls were identified as *Ozimops* species complex when the call shape was flat (slope S1 of less than 100 OPS generally) and the frequency was between 24 – 36 kHz. Gould's Wattled Bat was distinguished by a frequency of 27.5 – 32.5 kHz and alternation in call frequency between pulses. Inland Broad-nosed Bat calls have a slope of greater than 200 OPS, are non-alternating and fall between 29 and 34 kHz. When no distinguishing characteristics were present calls were assigned to multi-species groups.

In this geographic region, calls of Eastern Cave Bat, Little Forest Bat and Chocolate Wattled Bat overlap in the range 47 – 53 kHz. Chocolate Wattled Bat calls have a down-sweeping tail whereas Eastern Cave Bat and Little Forest Bat calls have an up-sweeping tail. Calls of the Eastern Cave Bat were separated from those of Little Forest Bat at frequencies above 50 kHz. When no distinguishing characteristics were present calls were assigned to multi-species groups or characterized as unidentifiable.

The calls of Large Bentwing Bat overlap in frequency with those of Southern Forest Bat and Little Forest Bat between 44 and 48.5 kHz and with Large Forest Bat at frequencies of 44 kHz. Large Bentwing Bat calls were distinguished by the following characteristics: a down-sweeping tail and the pulse shape and time between calls was variable (43 – 48.5 kHz). Southern Forest Bat, Large and Little Forest Bat calls are curved, have a regular pulse shape and generally up-sweeping tails. Large Forest Bat calls often have a longer characteristic section than Little or Southern forest Bats. When no distinguishing characteristics were present calls were assigned to multi-species groups.

Calls of *Scotorepens greyi*i (Little Broad-nosed Bat) (calls range between 36.5 – 40 kHz) and *Scotorepens species* (Central-eastern Broad-nosed Bat) (calls range between 38 – 41 kHz) can overlap in the range 38 – 40 kHz and where they overlap cannot be separated. There were no calls identified that fell in the range 38 – 41 kHz and so only Little Broad-nosed Bat was identified as being present in this survey.

Furthermore, calls produced by different bat species differ in fundamental ways related to the foraging mode / activity of each species. Calls of different species and the different types of calls produced by each species (cruise, search, social, approach, attack) are not equally recorded by ultrasonic detectors. Weather and climatic conditions affect the quality and quantity of recorded data as well as the availability of insect prey and therefore the suitability of each site at a given time as foraging habitat.

RESULTS TABLES FOR EACH ANABAT SWIFT

Table 5: Microbat species diversity and number of calls recorded ultrasonically at Wilpinjong BOA1 between 16 and 18 October 2019.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
***Chalinolobus dwyeri**[1]*	**Large-eared Pied Bat**	3	0	3
Chalinolobus gouldii / *Scotorepens balstoni*	Gould's Wattled Bat / Inland Broad-nosed Bat	0	1	1
Chalinolobus morio	Chocolate Wattled Bat	1	1	2
Chalinolobus morio / ***Vespadelus troughtoni**** / *Vespadelus vulturnus*	Chocolate Wattled Bat / **Eastern Cave Bat** / Little Forest Bat	0	1	1
Miniopterus orianae oceanensis*	**Large Bentwing Bat**	3	1	4
Miniopterus orianae oceanensis* / *Vespadelus darlingtoni* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Large Forest Bat / Little Forest Bat	0	4	4
Miniopterus orianae oceanensis* / *Vespadelus regulus* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Southern Forest Bat / Little Forest Bat	0	9	9
Miniopterus orianae oceanensis* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Little Forest Bat	0	16	16
Nyctophilus spp. In this region *N. geoffroyi, N. gouldii* and the threatened ***N. corbeni**[1]* are likely to be present.	In this region the Lesser, Gould's and the threatened **Corben's Long-eared Bats** are likely to be present.	2	1	3
Ozimops species complex. In this region the *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	7	7
Rhinolophus megaphyllus	Eastern Horseshoe Bat	7	0	7
Vespadelus regulus / *Vespadelus vulturnus*	Southern Forest Bat / Little Forest Bat	0	11	11
Vespadelus troughtoni* / *Vespadelus vulturnus*	**Eastern Cave Bat** / Little Forest Bat	0	4	4
Vespadelus vulturnus	Little Forest Bat	11	1	12
Unknown				70
Identifiable calls				84
Total Calls				154
Percentage identifiable calls				54.54

*listed as threatened under the BC Act and [1] listed as threatened under the EPBC Act

Table 6: Microbat species diversity and number of calls recorded ultrasonically at Wilpinjong BOA2 between 16 and 18 October 2019.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Austronomus australis	White-Striped Free-tailed Bat	8	0	8
Chalinolobus dwyeri*[1]	**Large-eared Pied Bat**	12	3	15
Chalinolobus gouldii	Gould's Wattled Bat	27	7	34
Chalinolobus gouldii / *Ozimops* species complex. In this region *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present.	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	35	35
Chalinolobus gouldii / *Scotorepens balstoni*	Gould's Wattled Bat / Inland Broad-nosed Bat	0	22	22
Chalinolobus morio	Chocolate Wattled Bat	22	16	38
Chalinolobus morio / ***Vespadelus troughtoni****	Chocolate Wattled Bat / **Eastern Cave Bat**	0	5	5
Chalinolobus morio / ***Vespadelus troughtoni**** / *Vespadelus vulturnus*	Chocolate Wattled Bat / **Eastern Cave Bat** / Little Forest Bat	0	14	14
Miniopterus orianae oceanensis*	**Large Bentwing Bat**	8	4	12
Miniopterus orianae oceanensis* / *Vespadelus darlingtoni* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Large Forest Bat / Little Forest Bat	0	2	2
Miniopterus orianae oceanensis* / *Vespadelus regulus* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Southern Forest Bat / Little Forest Bat	0	11	11
Miniopterus orianae oceanensis* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Little Forest Bat	0	36	36
Nyctophilus spp. In this region *N. geoffroyi*, *N. gouldii* and the threatened ***N. corbeni**[1]* are likely to be present.	In this region the Lesser, Gould's and the threatened **Corben's Long-eared Bats** are likely to be present.	2	0	2
Ozimops species complex. In this region the *O. petersi*,	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	149	149

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
O. ridei and *O. planiceps* are likely to be present.				
Rhinolophus megaphyllus	Eastern Horseshoe Bat	2	0	2
Scotorepens balstoni	Inland Broad-nosed Bat	4	6	10
Scotorepens greyii	Little Broad-nosed Bat	0	1	1
Vespadelus darlingtoni	Large Forest Bat	1	0	1
Vespadelus darlingtoni / *Vespadelus vulturnus*	Large Forest Bat / Little Forest Bat	0	2	2
Vespadelus regulus / *Vespadelus vulturnus*	Southern Forest Bat / Little Forest Bat	0	20	20
Vespadelus troughtoni*	**Eastern Cave Bat**	1	0	1
Vespadelus troughtoni* / *Vespadelus vulturnus*	**Eastern Cave Bat** / Little Forest Bat	0	3	3
Vespadelus vulturnus	Little Forest Bat	13	1	14
Unknown			q	151
Identifiable calls				438
Total Calls				588
Percentage identifiable calls				74.49

*listed as threatened under the BC Act and [1] listed as threatened under the EPBC Act

Table 7: Microbat species diversity and number of calls recorded ultrasonically at Wilpinjong BOA3 between 21 and 23 October 2019.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Chalinolobus dwyeri**[1]	**Large-eared Pied Bat**	15	1	16
Chalinolobus gouldii	Gould's Wattled Bat	3	0	3
Chalinolobus gouldii / *Ozimops* species complex. In this region *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present.	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	1	1
Chalinolobus morio	Chocolate Wattled Bat	43	14	57
Chalinolobus morio / ***Vespadelus troughtoni****	Chocolate Wattled Bat / **Eastern Cave Bat**	0	31	31
Chalinolobus morio / ***Vespadelus troughtoni**** / *Vespadelus vulturnus*	Chocolate Wattled Bat / **Eastern Cave Bat** / Little Forest Bat	0	4	4
Miniopterus orianae oceanensis*	**Large Bentwing Bat**	1	1	2

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Miniopterus orianae oceanensis* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Little Forest Bat	0	38	38
Ozimops species complex. In this region the *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	15	15
Rhinolophus megaphyllus	Eastern Horseshoe Bat	5	0	5
Scotorepens balstoni	Inland Broad-nosed Bat	0	1	1
Vespadelus regulus / *Vespadelus vulturnus*	Southern Forest Bat / Little Forest Bat	0	2	2
Vespadelus troughtoni* / *Vespadelus vulturnus*	**Eastern Cave Bat** / Little Forest Bat	0	3	3
Vespadelus vulturnus	Little Forest Bat	11	0	11
Unknown				143
Identifiable calls				187
Total Calls				332
Percentage identifiable calls				56.32

*listed as threatened under the BC Act and [1] listed as threatened under the EPBC Act

Table 8: Microbat species diversity and number of calls recorded ultrasonically at Wilpinjong BOA4 between 11 and 13 October 2019.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Chalinolobus dwyeri**[1]	**Large-eared Pied Bat**	10	3	13
Chalinolobus gouldii	Gould's Wattled Bat	1	1	2
Chalinolobus gouldii / *Ozimops* species complex. In this region *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present	0	4	4
Chalinolobus gouldii / *Scotorepens balstoni*	Gould's Wattled Bat / Inland Broad-nosed Bat	0	2	2
Chalinolobus morio	Chocolate Wattled Bat	1	4	5
Chalinolobus morio / ***Vespadelus troughtoni****	Chocolate Wattled Bat / **Eastern Cave Bat**	0	21	21
Chalinolobus morio / ***Vespadelus troughtoni**** / *Vespadelus vulturnus*	Chocolate Wattled Bat / **Eastern Cave Bat** / Little Forest Bat	0	7	7
Chalinolobus morio / *Vespadelus vulturnus*	Chocolate Wattled Bat / Little Forest Bat	0	1	1

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Miniopterus orianae oceanensis*	**Large Bentwing Bat**	2	2	4
Miniopterus orianae oceanensis* / *Vespadelus regulus* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Southern Forest Bat / Little Forest Bat	0	7	7
Miniopterus orianae oceanensis* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Little Forest Bat	0	27	27
Ozimops species complex. In this region the *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	4	4
Rhinolophus megaphyllus	Eastern Horseshoe Bat	3	0	3
Vespadelus regulus / *Vespadelus vulturnus*	Southern Forest Bat / Little Forest Bat	0	1	1
Vespadelus troughtoni* / *Vespadelus vulturnus*	**Eastern Cave Bat** / Little Forest Bat	0	3	3
Vespadelus vulturnus	Little Forest Bat	13	17	30
Unknown				288
Identifiable calls				134
Total Calls				422
Percentage identifiable calls				31.75

*listed as threatened under the BC Act and [1] listed as threatened under the EPBC Act

Table 9: Microbat species diversity and number of calls recorded ultrasonically at Wilpinjong BOA5 between 21 and 23 October 2019.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Chalinolobus dwyeri**[1]	**Large-eared Pied Bat**	2	1	3
Chalinolobus gouldii	Gould's Wattled Bat	0	1	1
Chalinolobus gouldii / *Ozimops* species complex. In this region *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present	0	2	2
Chalinolobus morio	Chocolate Wattled Bat	2	2	4
Chalinolobus morio / ***Vespadelus troughtoni****	Chocolate Wattled Bat / Eastern Cave Bat	0	1	1
Chalinolobus morio / ***Vespadelus troughtoni**** / *Vespadelus vulturnus*	Chocolate Wattled Bat / Eastern Cave Bat / Little Forest Bat	0	1	1

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Miniopterus orianae oceanensis*	**Large Bentwing Bat**	1	0	1
Miniopterus orianae oceanensis* / *Vespadelus regulus* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Southern Forest Bat / Little Forest Bat	0	11	11
Miniopterus orianae oceanensis* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Little Forest Bat	0	21	21
Ozimops species complex. In this region the *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	27	27
Rhinolophus megaphyllus	Eastern Horseshoe Bat	11	0	11
Scotorepens balstoni	Inland Broad-nosed Bat	1	1	2
Scotorepens greyii	Little Broad-nosed Bat	0	1	1
Vespadelus regulus / *Vespadelus vulturnus*	Southern Forest Bat / Little Forest Bat	0	2	2
Vespadelus troughtoni*	**Eastern Cave Bat**	1	0	1
Vespadelus troughtoni* / *Vespadelus vulturnus*	**Eastern Cave Bat** / Little Forest Bat	0	1	1
Vespadelus vulturnus	Little Forest Bat	9	2	11
Unknown				116
Identifiable calls				101
Total Calls				217
Percentage identifiable calls				46.54

*listed as threatened under the BC Act and [1] listed as threatened under the EPBC Act.

Table 10: Microbat species diversity and number of calls recorded ultrasonically at Wilpinjong ECA-A A-104 between 16 and 18 October 2019.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Austronomus australis	White-Striped Free-tailed Bat	2	0	2
Chalinolobus gouldii	Gould's Wattled Bat	0	1	1
Chalinolobus gouldii / *Ozimops* species complex. In this region *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present.	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	3	3
Chalinolobus gouldii / *Ozimops* species complex. In this region *O. petersi*, *O. ridei* and *O. planiceps* are likely to	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat	0	1	1

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
be present / *Scotorepens balstoni*	are likely to be present/ Inland Broad-nosed Bat			
Chalinolobus gouldii / *Scotorepens balstoni*	Gould's Wattled Bat / Inland Broad-nosed Bat	0	2	2
Chalinolobus morio	Chocolate Wattled Bat	0	1	1
Chalinolobus morio / ***Vespadelus troughtoni**** / *Vespadelus vulturnus*	Chocolate Wattled Bat / **Eastern Cave Bat** / Little Forest Bat	0	2	2
Miniopterus orianae oceanensis*	**Large Bentwing Bat**	0	2	2
Miniopterus orianae oceanensis* / *Vespadelus regulus* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Southern Forest Bat / Little Forest Bat	0	4	4
Miniopterus orianae oceanensis* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Little Forest Bat	0	2	2
Ozimops species complex. In this region the *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	23	23
Rhinolophus megaphyllus	Eastern Horseshoe Bat	1	0	1
Vespadelus troughtoni* / *Vespadelus vulturnus*	**Eastern Cave Bat** / Little Forest Bat	0	2	2
Vespadelus vulturnus	Little Forest Bat	1	0	1
Unknown				25
Identifiable calls				47
Total Calls				72
Percentage identifiable calls				65.27

*listed as threatened under the BC Act and [1] listed as threatened under the EPBC Act

Table 11: Microbat species diversity and number of calls recorded ultrasonically at Wilpinjong ECA-B B_101 between 11 and 13 November 2019.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Austronomus australis	White-Striped Free-tailed Bat	1	0	1
***Chalinolobus dwyeri**[1]*	**Large-eared Pied Bat**	7	2	9
Chalinolobus gouldii	Gould's Wattled Bat	16	2	18
Chalinolobus gouldii / *Ozimops* species complex. In	Gould's Wattled Bat / In this region the Inland, Ride's and	0	6	6

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
this region *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present.	South-eastern Free-tailed Bat are likely to be present.			
Chalinolobus gouldii / *Ozimops* species complex. In this region *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present/ *Scotorepens balstoni*	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present/ Inland Broad-nosed Bat	0	2	2
Chalinolobus gouldii / *Scotorepens balstoni*	Gould's Wattled Bat / Inland Broad-nosed Bat	0	5	5
Chalinolobus morio	Chocolate Wattled Bat	3	2	5
Chalinolobus morio / ***Vespadelus troughtoni****	Chocolate Wattled Bat /**Eastern Cave Bat**	0	55	55
Chalinolobus morio / ***Vespadelus troughtoni**** / *Vespadelus vulturnus*	Chocolate Wattled Bat / **Eastern Cave Bat** / Little Forest Bat	0	7	7
Miniopterus orianae oceanensis*	**Large Bentwing Bat**	7	6	13
Miniopterus orianae oceanensis* / *Vespadelus darlingtoni* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Large Forest Bat / Little Forest Bat	0	3	3
Miniopterus orianae oceanensis* / *Vespadelus regulus* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Southern Forest Bat / Little Forest Bat	0	20	20
Miniopterus orianae oceanensis* /*Vespadelus vulturnus*	**Large Bentwing Bat** / Little Forest Bat	0	110	110
Nyctophilus spp. In this region *N. geoffroyi, N. gouldii* and the threatened ***N. corbeni**[1]* are likely to be present.	In this region Lesser, Gould's and the threatened **Corben's Long-eared Bats** are likely to be present.	1	0	1
Ozimops species complex. In this region the *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	24	24
Scotorepens balstoni	Inland Broad-nosed Bat	6	2	8
Vespadelus darlingtoni / *Vespadelus vulturnus*	Large Forest Bat / Little Forest Bat	0	7	7
Vespadelus regulus / *Vespadelus vulturnus*	Southern Forest Bat / Little Forest Bat	0	35	35

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Vespadelus troughtoni*	**Eastern Cave Bat**	5	0	5
Vespadelus troughtoni* / *Vespadelus vulturnus*	**Eastern Cave Bat** / Little Forest Bat	0	25	25
Vespadelus vulturnus	Little Forest Bat	36	1	37
Unknown				168
Identifiable calls				396
Total Calls				564
Percentage identifiable calls				70.21

*listed as threatened under the BC Act and [1] listed as threatened under the EPBC Act

Table 12: Microbat species diversity and number of calls recorded ultrasonically at Wilpinjong ECA-C C-102 between 18 and 20 November 2019.

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Chalinolobus dwyeri**[1]	**Large-eared Pied Bat**	25	0	25
Chalinolobus gouldii	Gould's Wattled Bat	0	4	4
Chalinolobus gouldii / *Ozimops* species complex. In this region *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present.	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	3	3
Chalinolobus gouldii / *Ozimops* species complex. In this region *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present / *Scotorepens balstoni*	Gould's Wattled Bat / In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present/ Inland Broad-nosed Bat	0	1	1
Chalinolobus morio	Chocolate Wattled Bat	0	2	2
Miniopterus orianae oceanensis*	**Large Bentwing Bat**	0	3	3
Miniopterus orianae oceanensis* / *Vespadelus darlingtoni* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Large Forest Bat / Little Forest Bat	0	1	1
Miniopterus orianae oceanensis* / *Vespadelus regulus* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Southern Forest Bat / Little Forest Bat	0	3	3
Miniopterus orianae oceanensis* / *Vespadelus vulturnus*	**Large Bentwing Bat** / Little Forest Bat	0	10	10

Scientific Name	Common Name	Definitely present	Potentially present	Total calls
Ozimops species complex. In this region the *O. petersi*, *O. ridei* and *O. planiceps* are likely to be present.	In this region the Inland, Ride's and South-eastern Free-tailed Bat are likely to be present.	0	14	14
Vespadelus vulturnus	Little Forest Bat	0	1	1
Unknown				82
Identifiable calls				74
Total Calls				156
Percentage identifiable calls				47.44

*listed as threatened under the BC Act

TABLE EXAMPLE CALL PROFILES

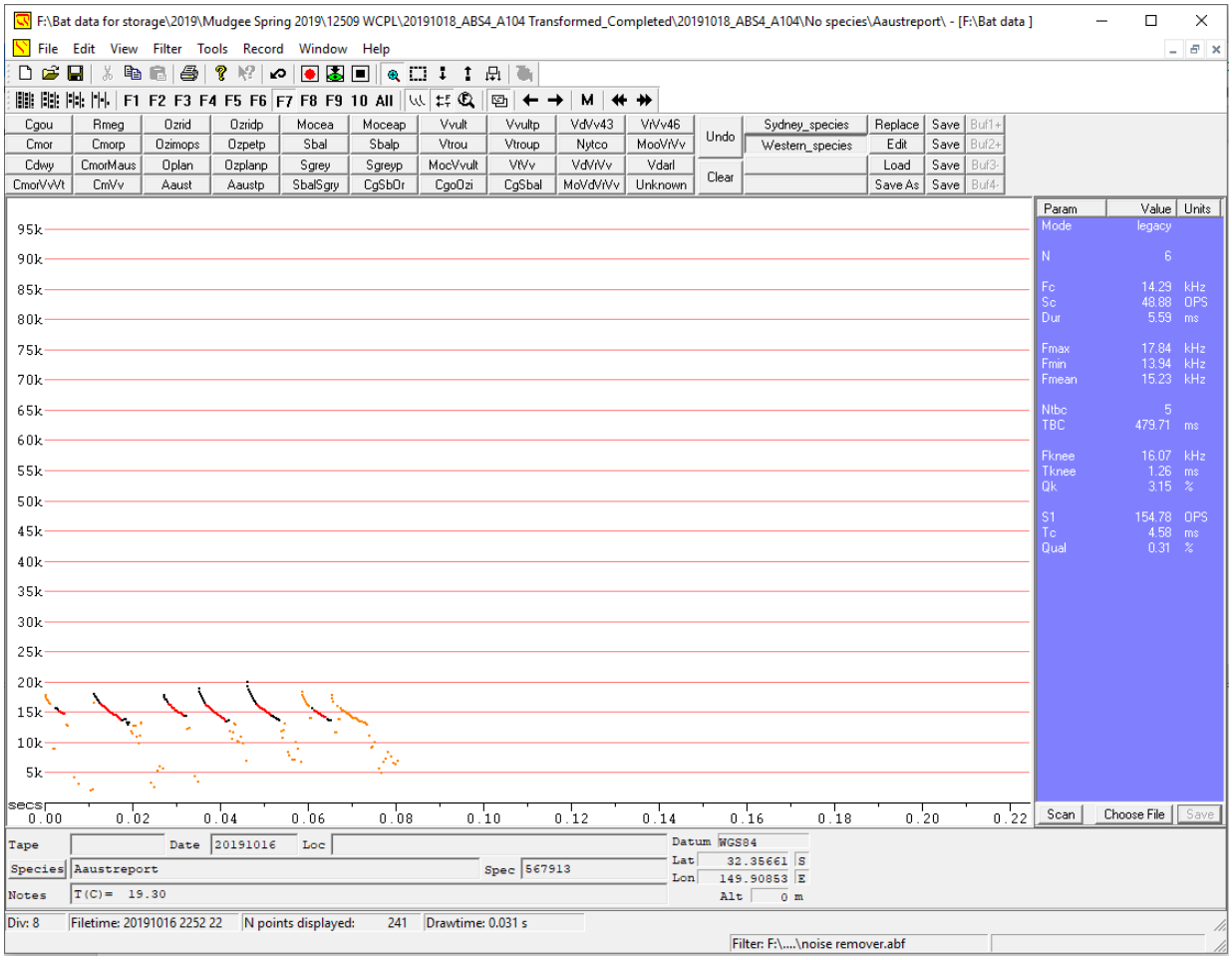

Figure 1. Call profile for *Austronomus australis* (White-striped Free-tailed Bat) recorded on the ECA-A A104 at 2252 (10:52 p.m.) on 16 October 2019.

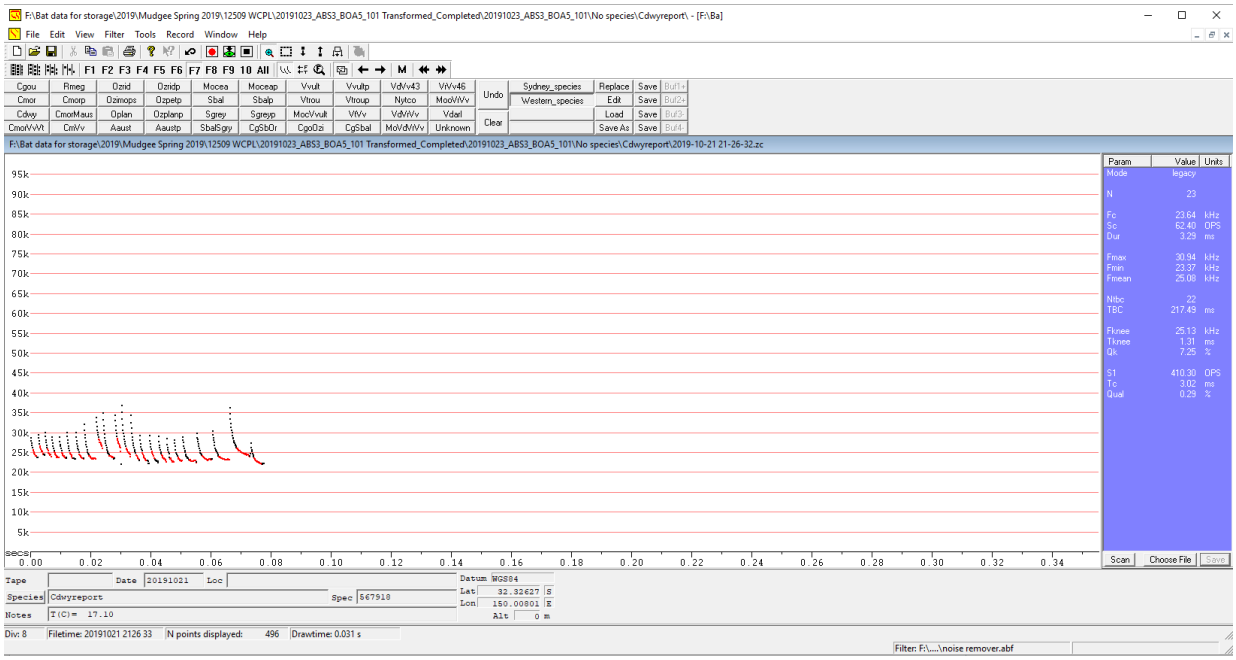

Figure 2. Call profile for *Chalinolobus dwyeri* (Large-eared Pied Bat) recorded at BOA5 at 2126 (9.26 p.m.) 21 October 2019.

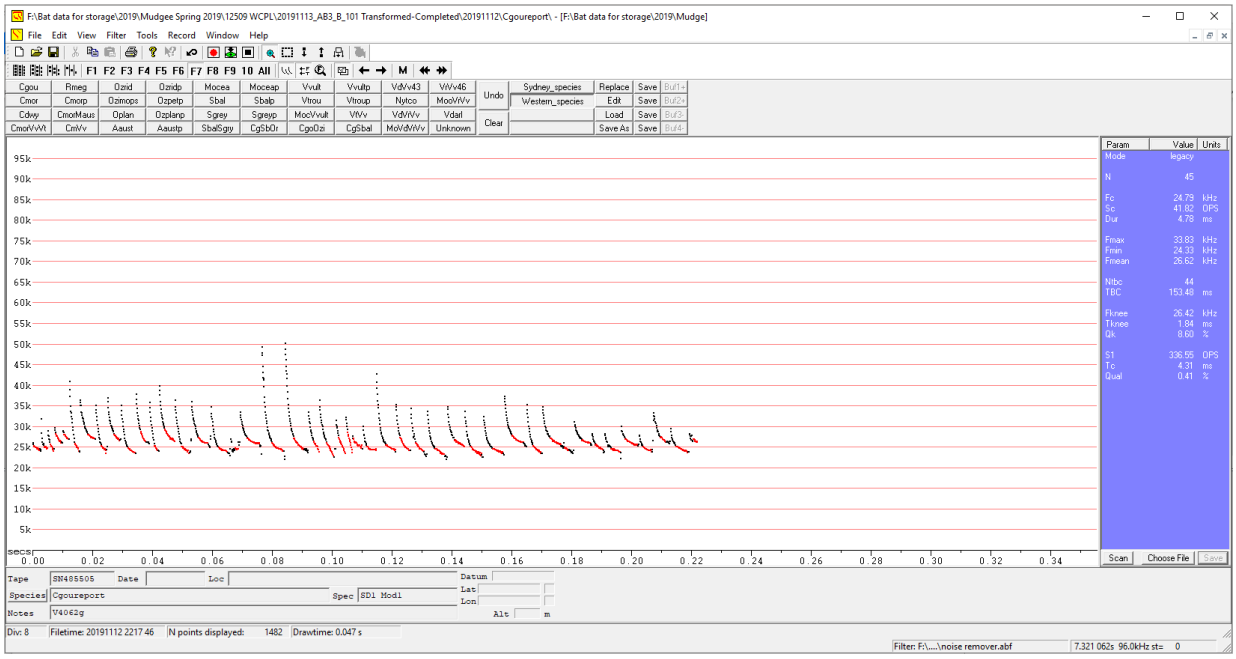

Figure 3. Call profile for *Chalinolobus gouldii* (Gould's Wattled Bat) recorded at ECA A A104 at 2217 (10.17 p.m.) 12 November 2019.

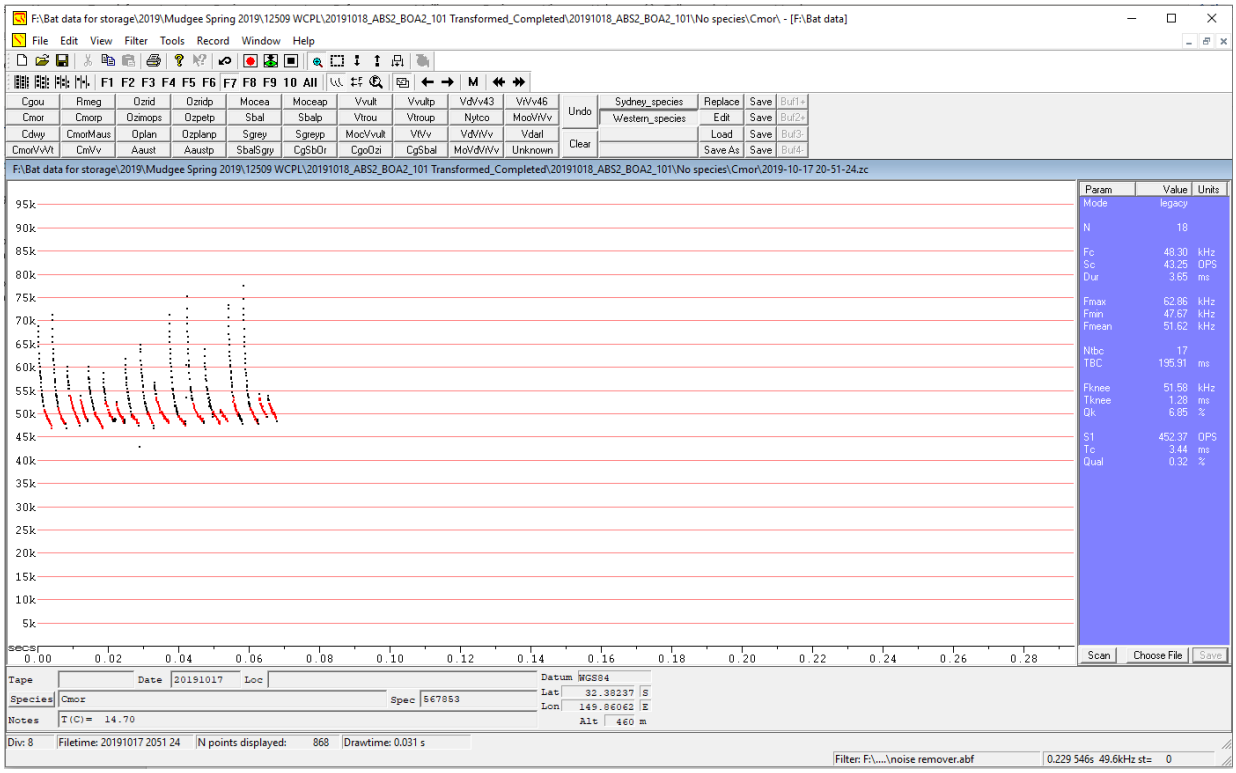

Figure 4. Call profile for *Chalinolobus morio* (Chocolate Wattled Bat) recorded on the BOA2 at 2051 (8.51 p.m.) on 17 October 2019.

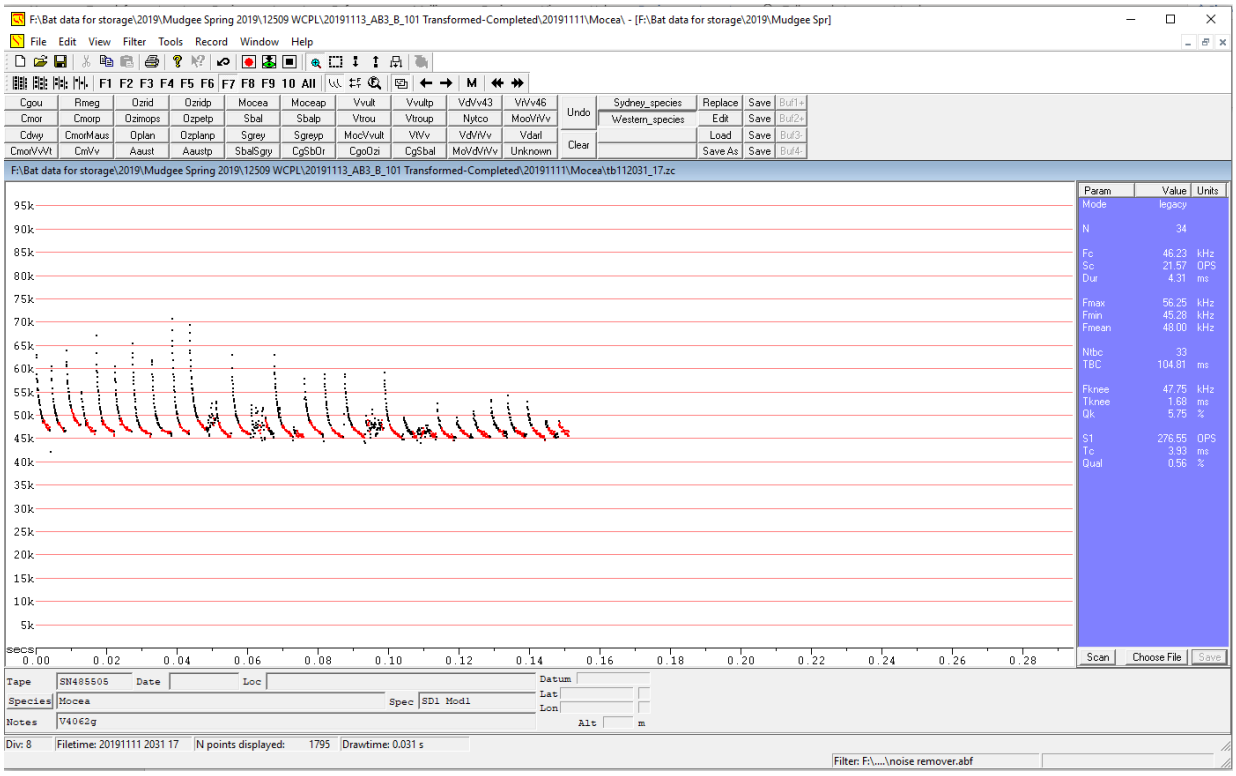

Figure 5. Call profile for *Miniopterus orianae oceanensis* (Large Bentwing Bat) recorded at AEC-B B-101 at 2031 (8:31 p.m.) on 11 November 2019.

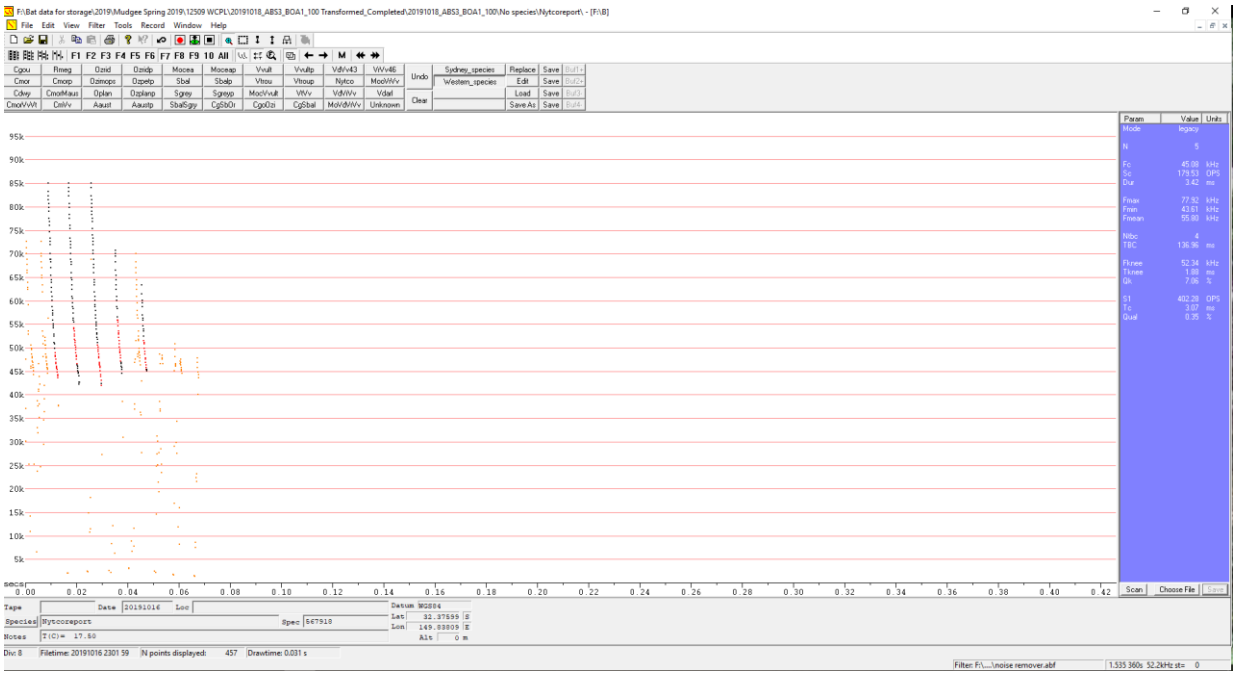

Figure 6. Potential call profile for *Nyctophilus corbeni* (Corben's Large-eared Bat) / *Nyctophilus gouldii* (Gould's Long-eared Bat) / *Nyctophilus geoffroyi* (Lesser Long-eared Bat) recorded at BOA1 at 2301 (11:01pm) on 16 October 2019.

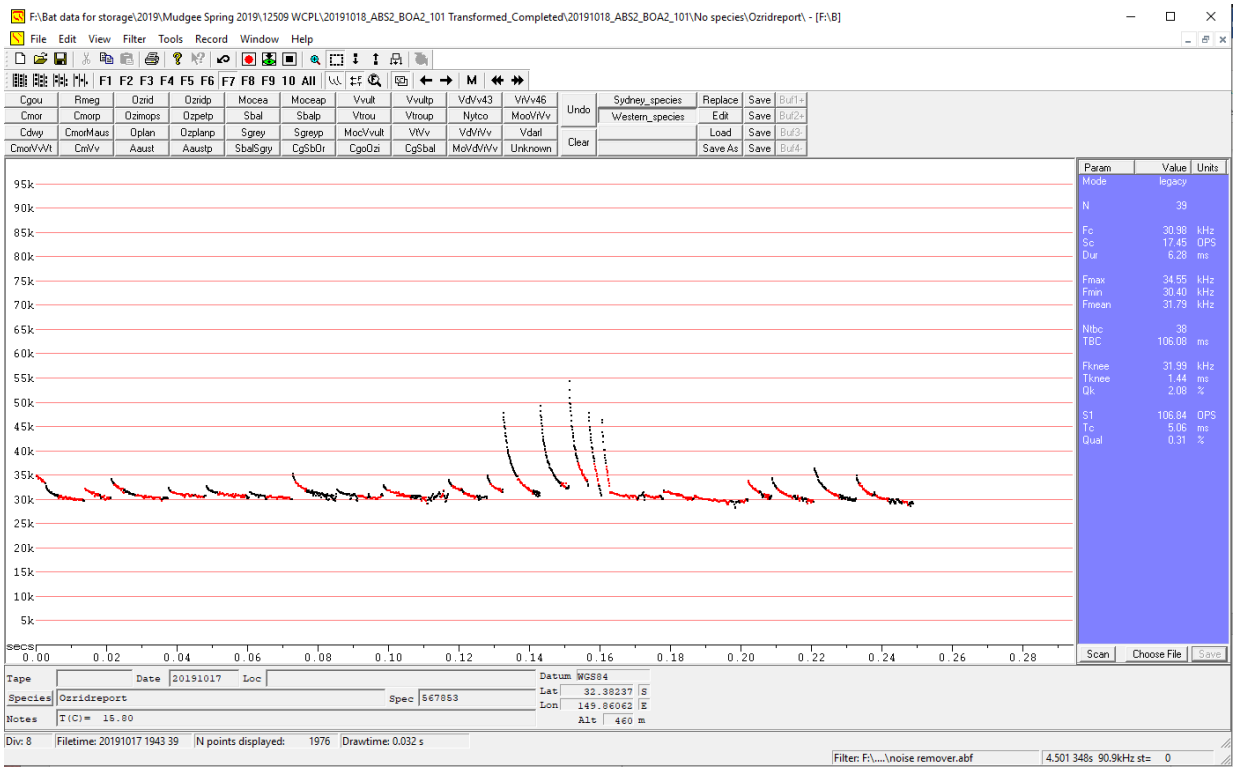

Figure 7. Call profile for *Ozimops* species complex (this is a call profile that can be attributed to Ozimops ridei (Ride's Free-tailed Bat), *Ozimops petersi* (Inland Free-tailed Bat) or *Ozimops ridei* (Ride's Free-tailed Bat)) recorded at BOA2 at 1943 (7:43pm) on 17 October 2019.

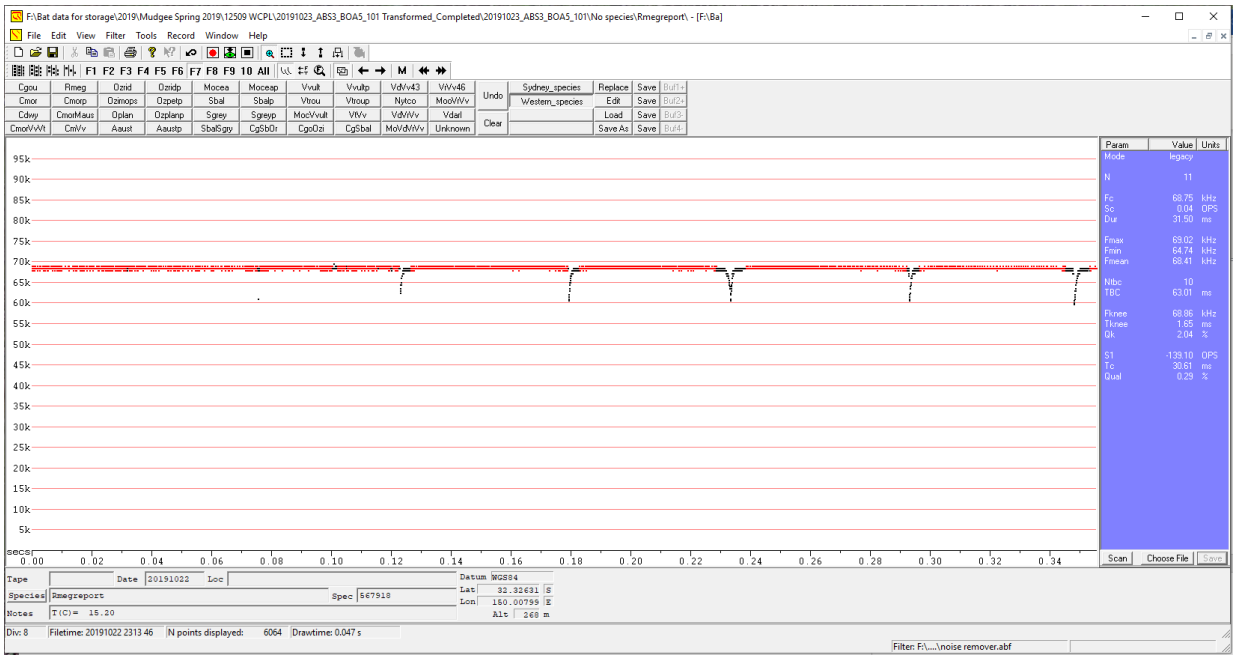

Figure 8. Call profile for *Rhinolophus megaphyllus* (Eastern Horseshoe Bat) recorded at BOA5 at 2313 (11:13 p.m.) on 22 October 2019.

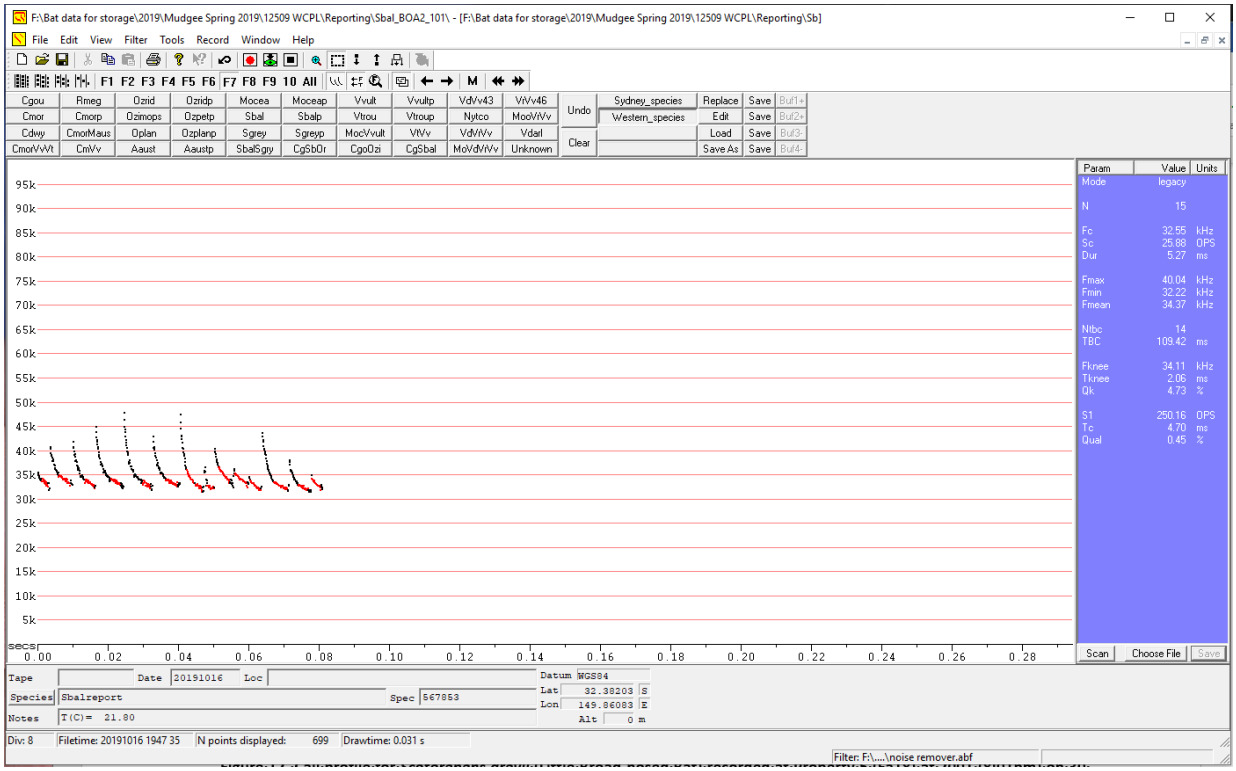

Figure 9. Call profile for *Scotorepens balstoni* (Inland Broad-nosed Bat) recorded at BOA2 at 1947 (7:47pm) on 16 October 2019.

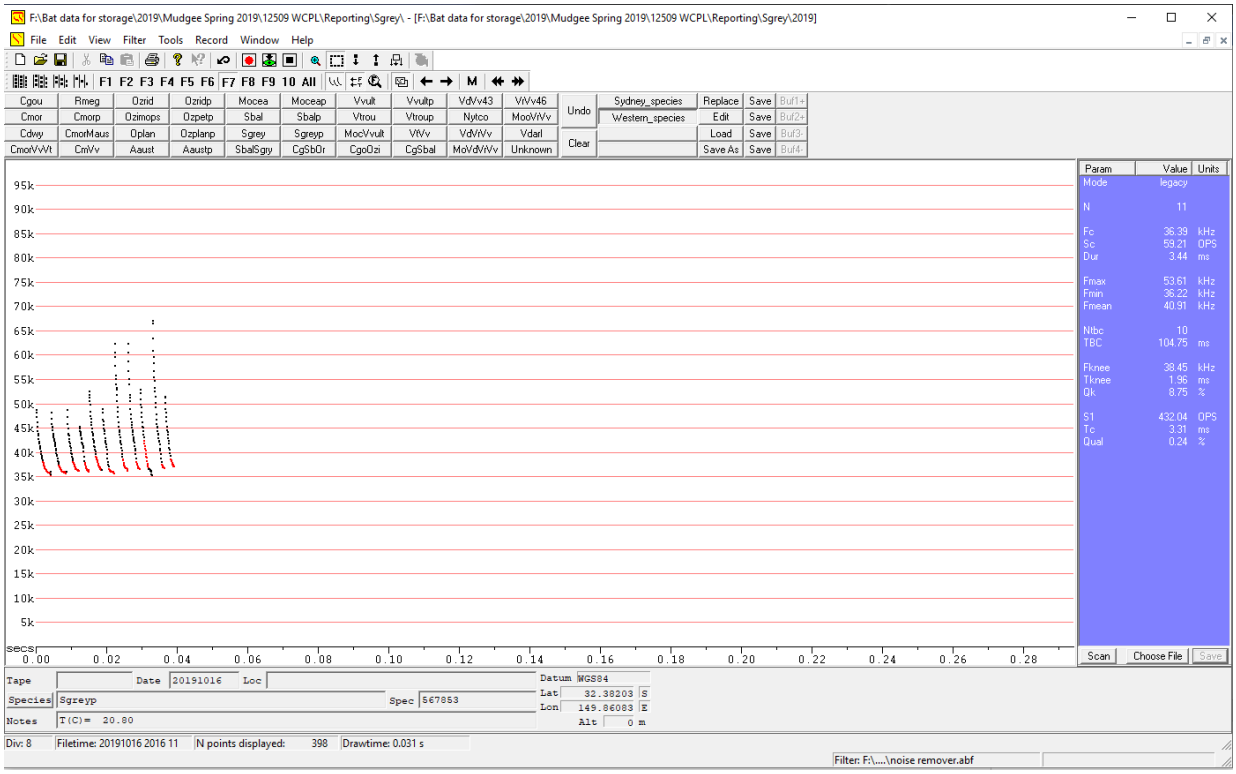

Figure 10. Potential call profile for *Scotorepens greyii* (Little Broad-nosed Bat) recorded at BOA2 at 2016 (8:16 p.m.) on 16 October 2019.

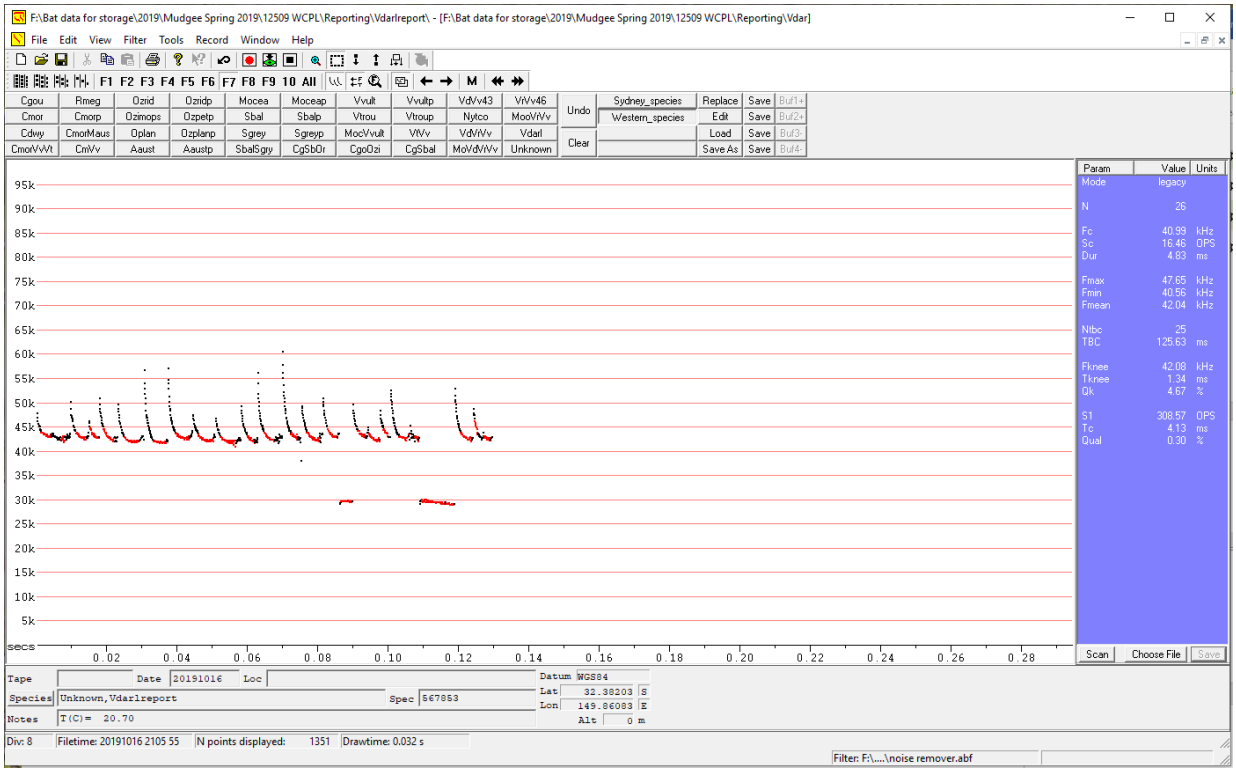

Figure 11. Call profile for *Vespadelus darlingtoni* (Large Forest Bat) recorded at BOA2 at 2105 (9:05 p.m.) on 16 October 2019.

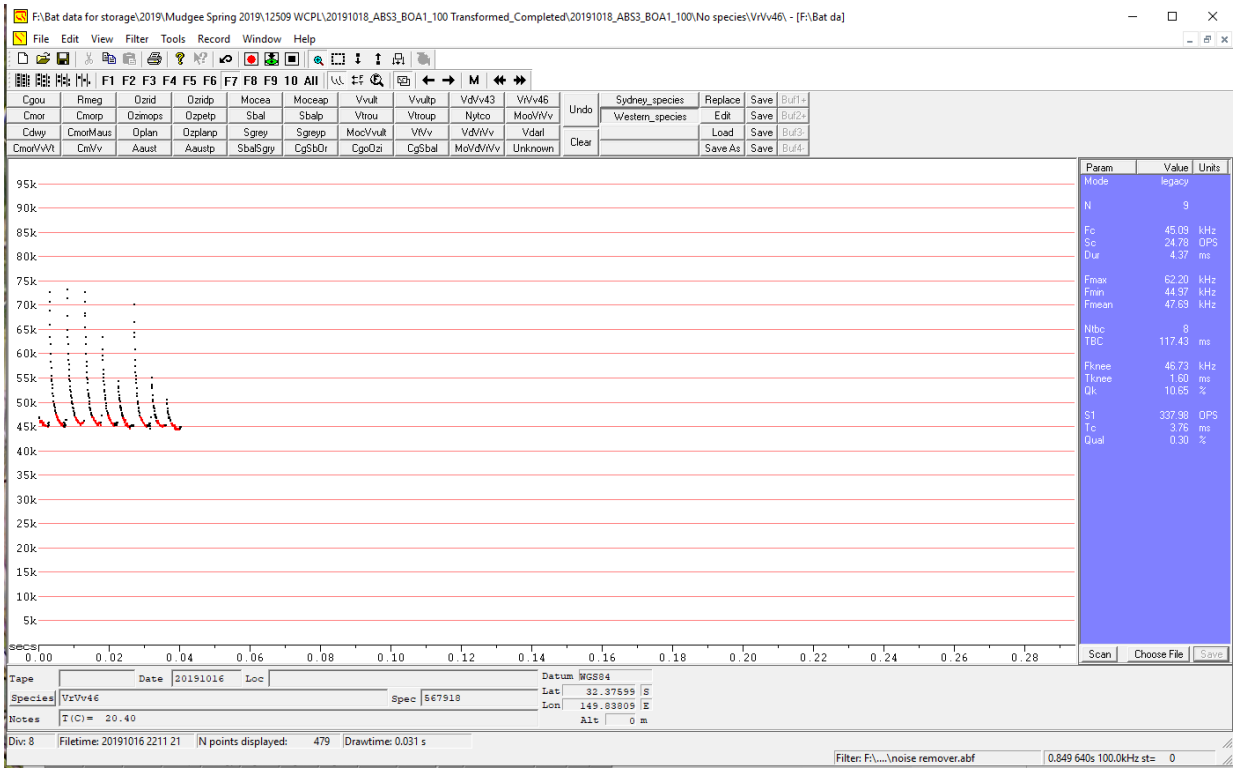

Figure 12. Potential call profile for *Vespadelus regulus* (Southern Forest Bat) or *Vespadelus vulturnus* (Little Forest Bat) recorded at BOA1 at 2211 (22:11 p.m.) on 16 October 2019.

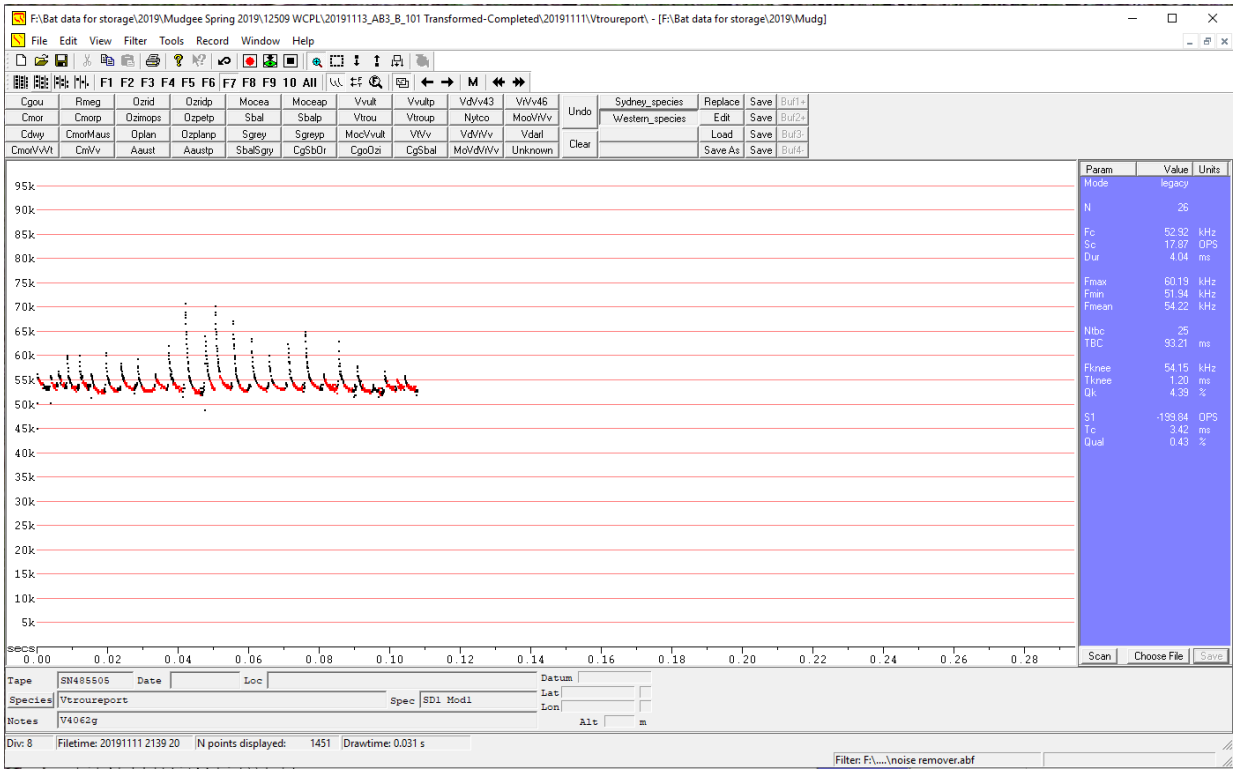

Figure 13. Call profile for *Vespadelus troughtoni* (Eastern Cave Bat) recorded ECA-B B-101 at 2139 (9:39 p.m.) on 11 November 2019.

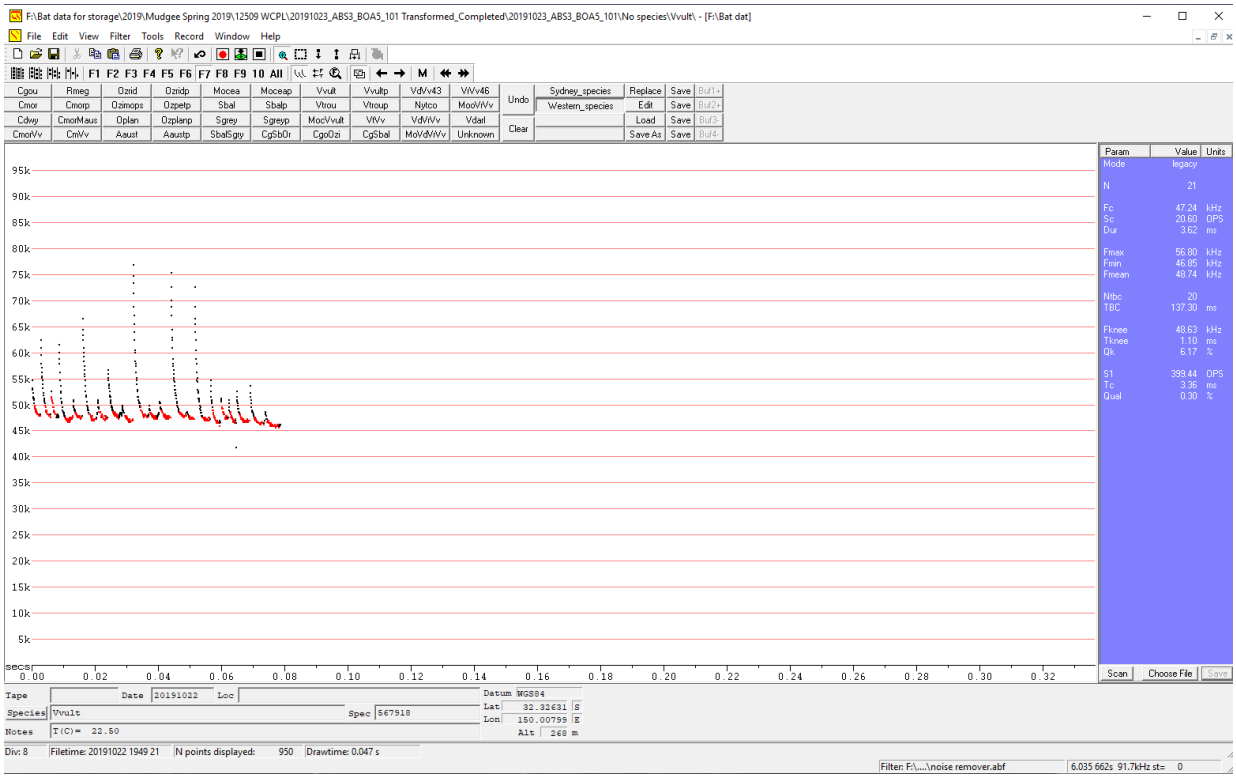

Figure 14. Call profile for *Vespadelus vulturnus* (Little Forest Bat) recorded at BOA5 at 1949 (7:49 p.m.) on 22 October 2019.

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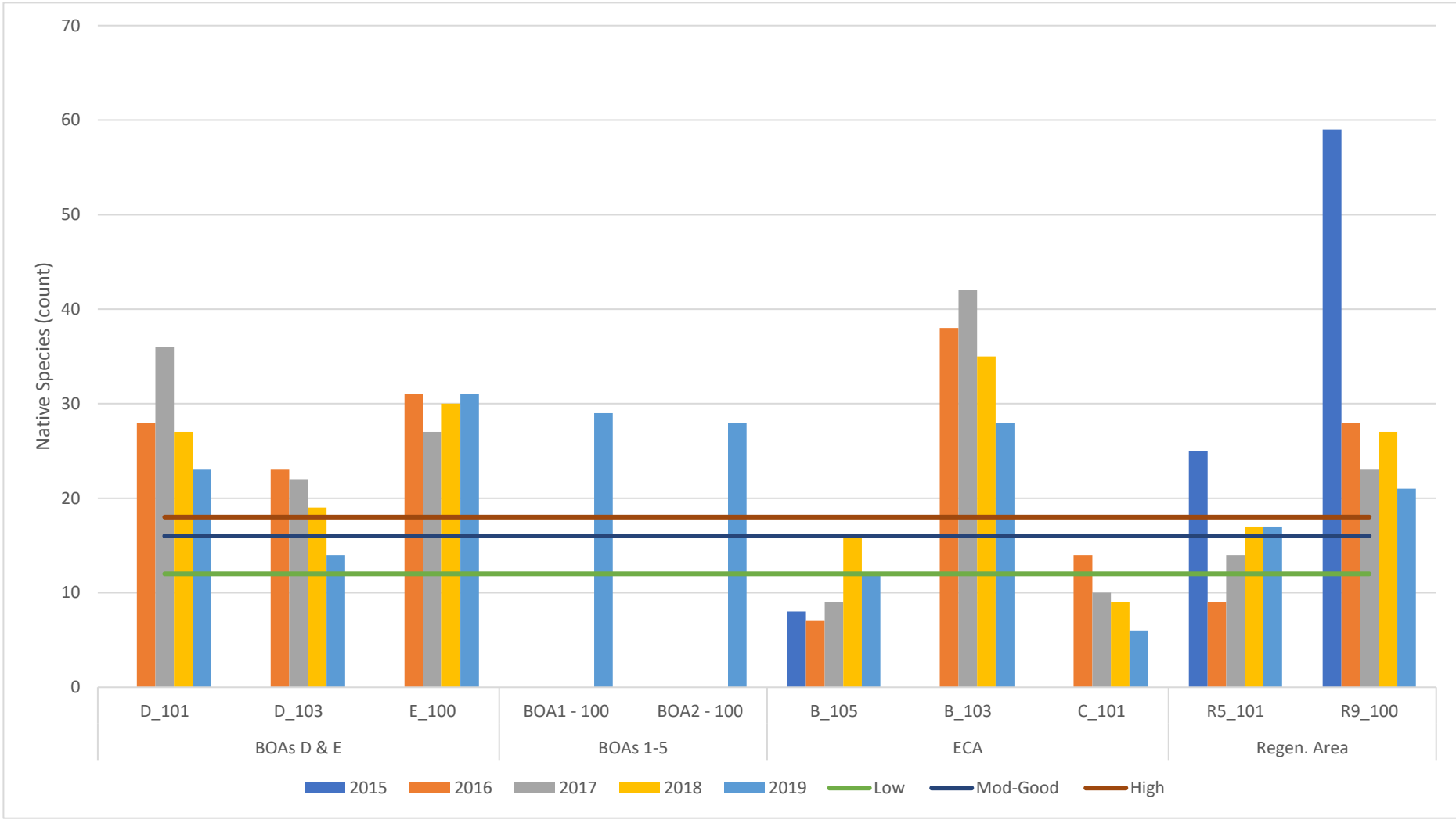
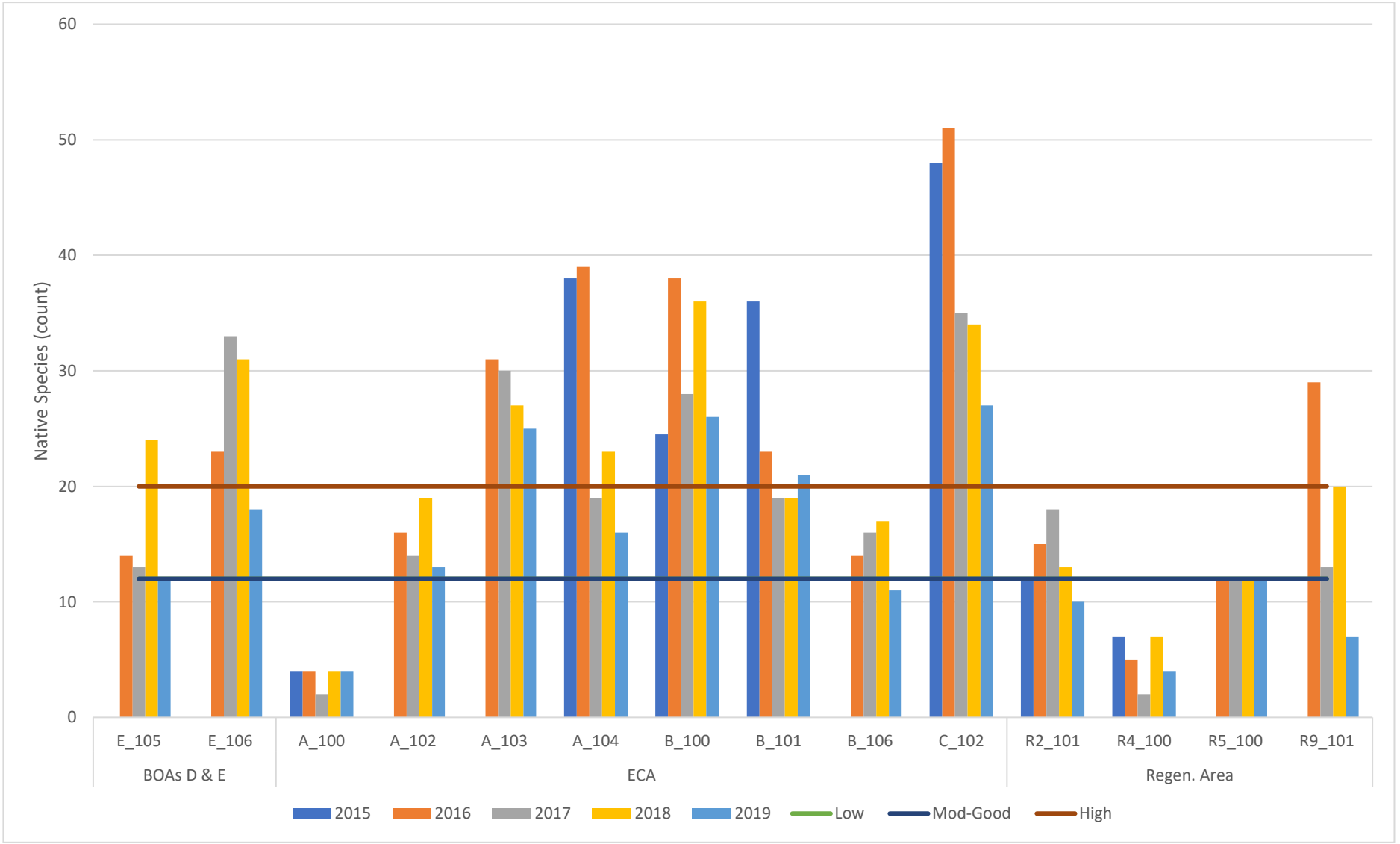
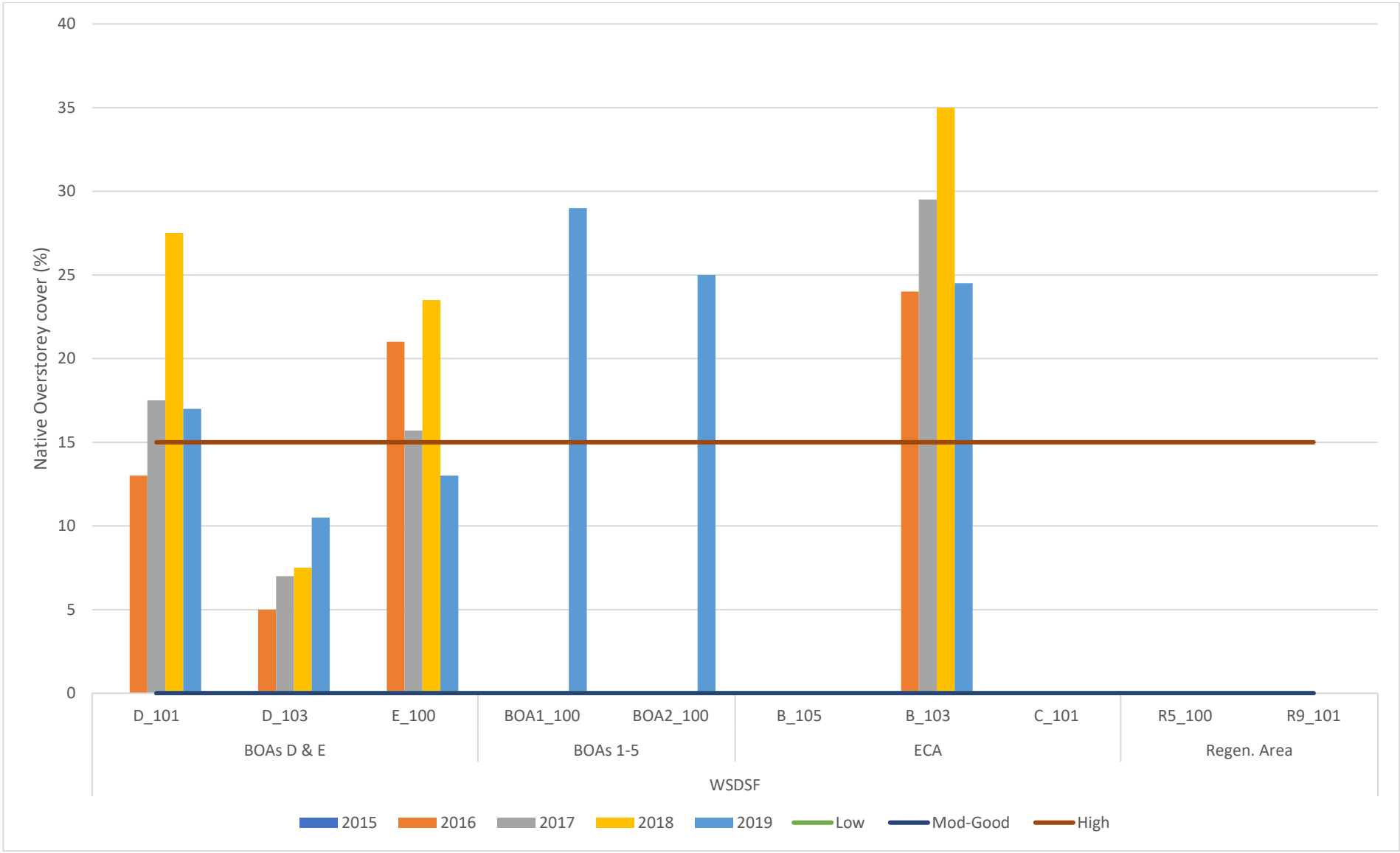
Appendix E – Biometric Attribute Graphs



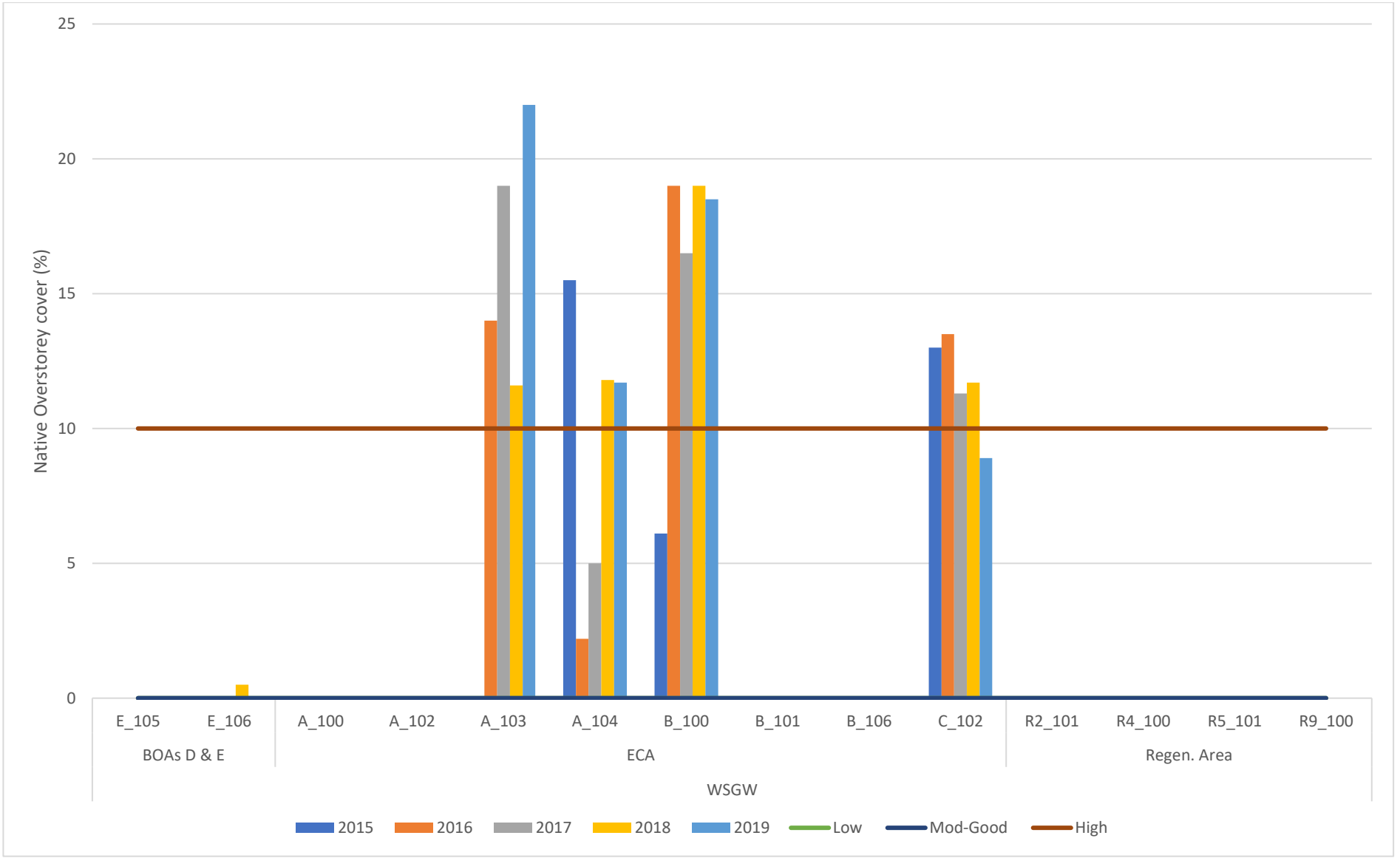
Native species richness compared with the IPT – Spring and Autumn 2015 – 2019 for WSDSF



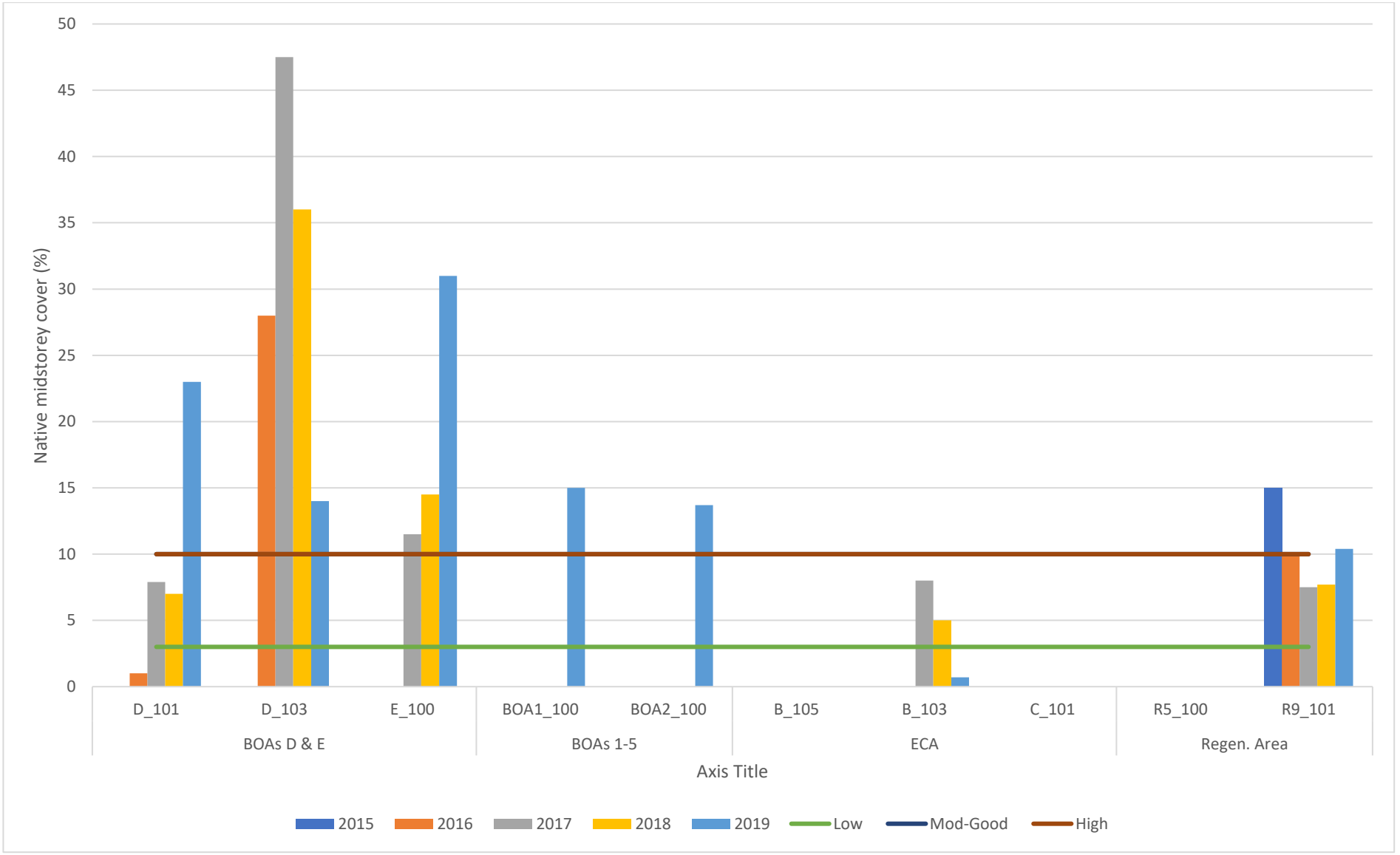
Native species richness compared with the IPT – Spring and Autumn 2015 – 2019 for WSGW



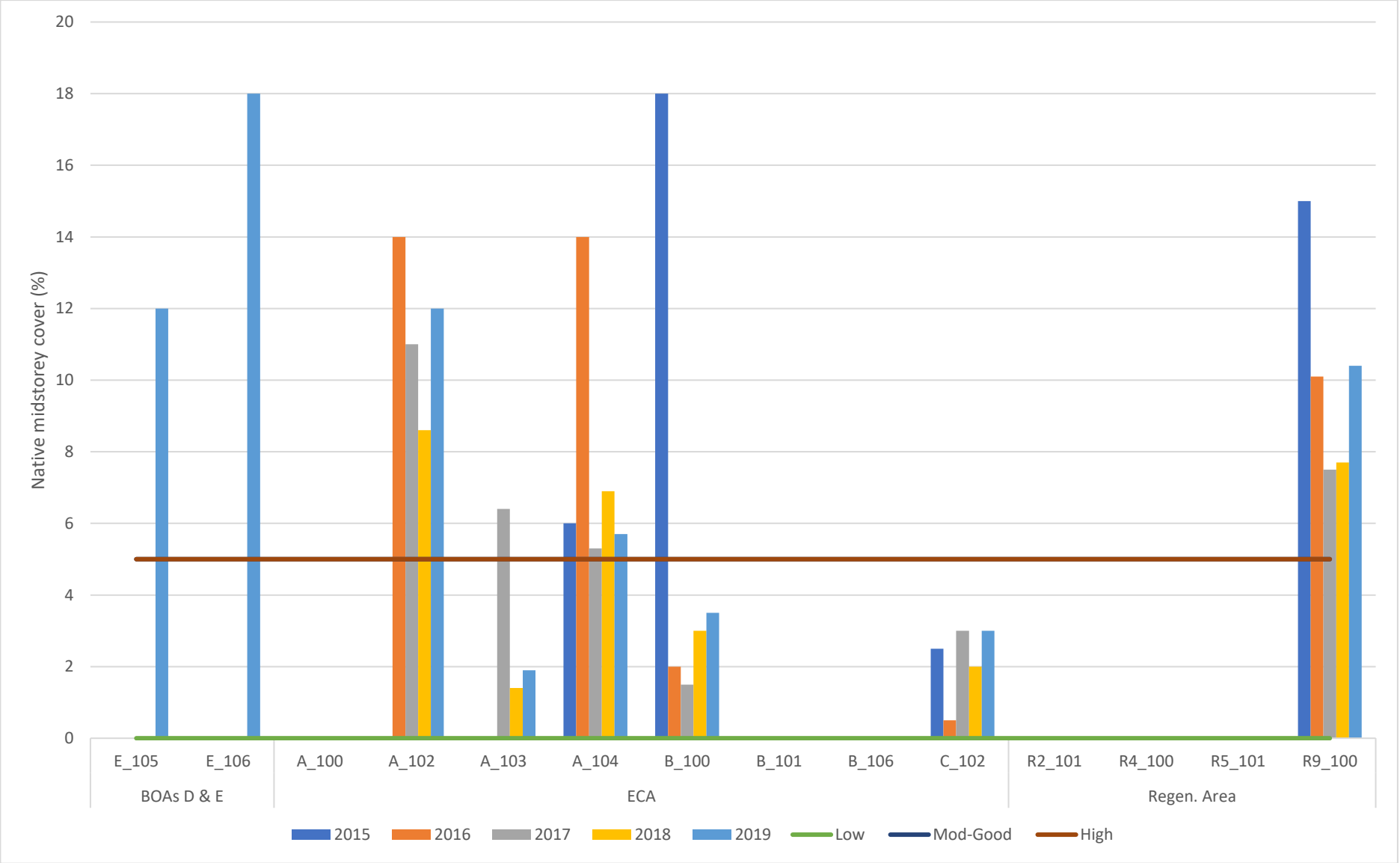
Native overstorey cover for all sites from 2015 to 2019 compared against the 1-5 year IPT for WSDSF



Native overstorey cover for all sites from 2015 to 2019 compared against the 1-5 year IPT for WSGW



Native Midstorey cover for all sites from 2015 to 2019 compared against the 1-5 year IPT WSDSF



Native Midstorey cover for all sites from 2015 to 2019 compared against the 1-5 year IPT for WSGW

Appendix F - Biometric Performance and Completion Criteria

Performance and Completion Criteria were approved by DPIE on 23 April 2019. This table is incorporated into the revised BMP (WCPL 2019), which is pending approval by DPIE. These performance and completion criteria are applicable to Rehabilitation Areas monitoring sites.

Table 12 Biometric Performance & Completion Criteria

Attribute (OEH, 2017)	BVT	Native Plant Species Richness (No. species)		Native Over Storey Cover MIN-MAX (%)[7]		Native Mid – Storey Cover MIN-MAX (%)		Native Ground Cover Grass MIN-MAX (%)		Native Ground Cover Shrubs MIN-MAX (%)		Native Ground Cover Other MIN-MAX (%)		Number of Trees with Hollows	Total Length Fallen Logs (m)	
BVT Benchmark (OEH, 2017)	HU547	23		10-45		5-60		5-45		2-10		5-35		2	50	
	HU732	35		10-50		2-10		10-60		2-10		5-30		1.5	25	
	HU697	25		20-50		10-60		5-15		5-10		5-15		0.8	46	
	HU824	25		20-50		10-60		5-15		5-10		5-15		0.8	66	
	HU825	35		25-40		11-50		5-45		5-30		5-20		3	73	
Completion Criteria		**1**		**1**		**1**		**1**		**1**		**1**		**0**	**0.5**	
Allowable Future Attribute Score Increases Relative to Benchmark (After OEH, 2014b, 2015)		**>50%**		**>25<200%**		**>25<200%**		**>25<200%**		**>25<200%**		**>25<200%**		**N/A**	**>25%**	
WCPL Criteria	**BVT**	**Comp.**	**Perf.**	**Comp.**	**Perf.**	**Comp.**	**Perf.**	**Comp.**	**Perf.**	**Comp.**	**Perf.**	**Comp.**	**Perf.**		**Comp.**	**Perf.**
	HU547	11.5	6	2.5-90	1-90	1.25-100	1-100	1.25-90	1-90	0.5-20	0-10	1.25-70	0.5-70		12.5	6
	HU732	17.5	9	2.5-100	1-100	0.5-20	0-20	2.5-100	1-100	0.5-20	0-10	1.25-60	0.5-60	NIL	6.25	3
	HU697	12.5	6	5-100	3-100	2.5-100	1-100	1.25-30	1-60	1.25-20	1-10	1.25-30	0.5-60		11.5	6
	HU824	12.5	6	5-100	3-100	2.5-100	1-100	1.25-30	1-60	1.25-20	1-10	1.25-30	0.5-60		16.5	8
	HU825	17.5	9	6.25-80	3-80	2.75-100	1-100	1.25-90	1-90	1.25-60	1-30	1.25-40	0.5-80		18.25	9

Attribute (OEH, 2017)	Exotic Plant Cover (% of total cover)		Regeneration[7] (% of over-storey species that are naturally regenerating)		Overall Site Value Score (OEH, 2015) (average of plots in vegetation zone)	
Completion Criteria	**1**		**0.5**			
Allowable Future Attribute Score Increases Relative to Benchmark (After OEH, 2014b, 2015)	**<45%**		**25%**		**16.93**	
WCPL Criteria	**Comp.**	**Perf.**	**Comp.**	**Perf.**	**Comp.**	**Perf.**
All relevant BVTs	<45%	<90%	To be determined based on number of OS species	No regeneration	17	7

[7] Relevant Regent Honeyeater habitat criteria
Comp. = Completion Criteria
Perf. = Performance Criteria at 10 years after landform establishment

Appendix G - Interim Performance Targets / Benchmark Values

The following Interim Performance Targets and Benchmark Values are shown in the current BM (WCPL 2017). These IPTs will be superseded once the new BVT reference sites are established and accepted by DPIE, and the revised BMP (WCPL 2019) is approved. These are currently applicable to BOAs, ECAs, regeneration areas and reference sites.

Table G - 1: Vegetation class benchmark condition state (WCPL 2017)

Vegetation Class	Site Attribute									
	NSR (count)	NOC	NMS	NGCG	NGCS	NGCO	EC	NTH (count)	OR	FL (m)
Western Slopes Dry Sclerophyll Forests	≥32	15 - 40	10 - 55	3 - 10	5 - 15	5 - 25	<5%	≥3	1	≥70
Western Slopes Grassy Woodlands	<35	6 - 25	14 - 50	3 - 35	3 - 25	5 - 1 - 40	<5%	≥2	1	<66

Table G - 2: Interim Performance Targets for Western Slopes Dry Sclerophyll Forests

Management Period	Interim Performance Target (site value score)	Site Attributes (% cover)									
		NSR (count)	NOC	NMS	NGCG	NGCS	NGCO	EC	NTH (count)	OR	FL (m)
Low Condition Vegetation											
Year 0 (Baseline)	6	<8	0	0	1	0	0	60	0	0	0
Years 1-5	34	12	0	3-10	1-2	1-5	1-3	60	0	1	10
Benchmark	>78	≥32	15-40	10-55	3-10	5-15	5-25	<5	≥3	1	≥70
Moderate to Good Condition Vegetation											
Year 0 (Baseline)	34	12	0	10	<3	<5	<4	60	0	1	10
Years 1-5	45	16	0	10-55	3-10	5-15	5-25	40	0	1	10

Management Period	Interim Performance Target (site value score)	Site Attributes (% cover)									
		NSR (count)	NOC	NMS	NGCG	NGCS	NGCO	EC	NTH (count)	OR	FL (m)
Benchmark	>78	≥32	15-40	10-55	3-10	5-15	5-25	<5	≥3	1	≥70
High Condition Vegetation											
Year 0 (Baseline)	70	18-32	15-40	10-55	3 -10	5-15	5-25	≤5	0	1	≥70
Years 1-20	70	18-32	15-40	10-55	3 -10	5-15	5-25	≤5	0	1	≥70
Benchmark	>78	≥32	15-40	10-55	3 -10	5-15	5-25	≤5	≥3	1	≥70

Table G - 3: Interim Performance Targets for Western Slopes Grassy Woodlands

Management period	Interim Performance Target (Site value score)	Site Attributes (% cover)									
		NSR (count)	NOC	NMS	NGCG	NGCS	NGCO	EC	NTH (count)	OR	FL (m)
Low Condition Vegetation											
Year 0 (Baseline)	7	<9	0	0	5	0	0	60	0	0	0
Years 1-5	34	12	0	<4	60+	<2	<2	60	0	1	10
Benchmark	>78	≥23	10-45	5-60	5-45	2-10	5-35	<5	≥2	1	≥50
Moderate to Good Condition Vegetation											
Year 0 (Baseline)	34	12	0	≤3	60+	<2	<2	60	0	1	10
Years 1-5	45	12	0	5-60	45-60	<2	<2	40	0	1	10
Benchmark	>78	≥23	10-45	5-60	5-45	2-10	5-35	<5	≥2	1	≥50
High Condition Vegetation											
Year 0 (Baseline)	70	20-22	10-45	5-60	5-45	2-10	5-35	≤20	0	1	≥50
Years 1-20	70	20-23	10-45	5-60	5-45	2-10	5-35	≤20	0	1	≥50
Benchmark	>78	≥23	10-45	5-60	5-45	2-10	5-35	<5	≥2	1	≥50

Appendix H - Flora species list (Autumn 2019 and Spring 2019)

Family	Scientific Name	Native / Exotic
Anthericaceae	*Laxmannia gracilis*	Native
Apiaceae	*Cyclospermum leptophyllum*	Exotic
Apiaceae	*Hydrocotyle laxiflora*	Native
Apocynaceae	*Gomphocarpus sp.*	Native/exotic
Aspleniaceae	*Asplenium flabellifolium*	Native
Asteraceae	*Arctotheca calendula*	Exotic
Asteraceae	*Asteraceae sp.*	Native/exotic
Asteraceae	*Calotis cuneifolia*	Native
Asteraceae	*Calotis lappulacea*	Native
Asteraceae	*Carthamus lanatus*	Exotic
Asteraceae	*Cassinia arcuata*	Native
Asteraceae	*Cassinia cunninghami*	Native
Asteraceae	*Cassinia quinquefaria*	Native
Asteraceae	*Chondrilla juncea*	Exotic
Asteraceae	*Chrysocephalum apiculatum*	Native
Asteraceae	*Cichorium intybus*	Exotic
Asteraceae	*Cirsium vulgare*	Exotic
Asteraceae	*Conyza bonariensis*	Exotic
Asteraceae	*Conyza sp.*	Exotic
Asteraceae	*Cotula australis*	Native
Asteraceae	*Euchiton sp.*	Native
Asteraceae	*Gamochaeta sp.*	Exotic
Asteraceae	*Hypochaeris radicata*	Exotic
Asteraceae	*Lactuca saligna*	Exotic
Asteraceae	*Legnephora stipitata*	Native
Asteraceae	*Olearia elliptica*	Native
Asteraceae	*Senecio quadridentatus*	Native
Asteraceae	*Solenogyne bellioides*	Native
Asteraceae	*Solenogyne sp.*	Native
Asteraceae	*Sonchus oleraceus*	Exotic
Asteraceae	*Sonchus sp.*	Exotic
Asteraceae	*Taraxacum officinale*	Exotic
Asteraceae	*Triptilodiscus pygmaeus*	Native
Asteraceae	*Vittadinia cuneata*	Native

Family	Scientific Name	Native / Exotic
Asteraceae	*Vittadinia sp.*	Native
Asteraceae	*Vittadinia muelleri*	Native
Boraginaceae	*Cynoglossum australe*	Native
Boraginaceae	*Echium plantagineum*	Exotic
Boraginaceae	*Echium vulgare*	Exotic
Boraginaceae	*Heliotropium amplexicaule*	Exotic
Brassicaceae	*Lepidium sp.*	Exotic
Brassicaceae	*Rapistrum rugosum*	Exotic
Cactaceae	*Opuntia sp.*	Exotic
Campanulaceae	*Wahlenbergia sp.*	Native
Caryophyllaceae	*Cerastium glomeratum*	Exotic
Caryophyllaceae	*Paronychia brasiliana*	Exotic
Caryophyllaceae	*Stellaria pungens*	Native
Casuarinaceae	*Allocasuarina gymnanthera*	Native
Casuarinaceae	*Allocasuarina sp.*	Native
Chenopodiaceae	*Dysphania pumilio*	Native
Chenopodiaceae	*Einadia nutans*	Native
Chenopodiaceae	*Einadia polygonoides*	Native
Chenopodiaceae	*Einadia sp.*	Native
Chenopodiaceae	*Einadia trigonos*	Native
Clusiaceae	*Hypericum gramineum*	Native
Clusiaceae	*Hypericum perforatum*	Exotic
Convolvulaceae	*Dichondra repens*	Native
Convolvulaceae	*Dichondra sp.*	Native
Crassulaceae	*Crassula sieberiana*	Native
Cucurbitaceae	*Cucumis myriocarpus subsp. leptodermis*	Exotic
Cupressaceae	*Callitris endlicheri*	Native
Cyperaceae	*Carex appressa*	Native
Cyperaceae	*Cyperus gracilis*	Native
Cyperaceae	*Cyperus sp.*	Native/exotic
Cyperaceae	*Gahnia aspera*	Native
Cyperaceae	*Lepidosperma laterale*	Native
Cyperaceae	*Leptospermum parvifolium*	Native
Dilleniaceae	*Hibbertia circumdans*	Native
Dilleniaceae	*Hibbertia obtusifolia*	Native
Dilleniaceae	*Hibbertia riparia*	Native
Epacridaceae	*Acrotriche rigida*	Native

Family	Scientific Name	Native / Exotic
Epacridaceae	*Melichrus erubescens*	Native
Epacridaceae	*Melichrus procumbens*	Native
Epacridaceae	*Melichrus urceolatus*	Native
Epacridaceae	*Styphelia triflora*	Native
Ericaceae	*Astroloma humifusum*	Native
Ericaceae	*Brachyloma daphnoides*	Native
Ericaceae	*Leucopogon muticus*	Native
Ericaceae	*Lissanthe strigosa*	Native
Ericaceae	*Monotoca scoparia*	Native
Fabaceae	*Acacia decora*	Native
Fabaceae	*Acacia implexa*	Native
Fabaceae	*Acacia ixiophylla*	Native
Fabaceae	*Acacia leucolobia*	Native
Fabaceae	*Acacia linearifolia*	Native
Fabaceae	*Acacia montana*	Native
Fabaceae	*Acacia spectabilis*	Native
Fabaceae	*Acacia triptera*	Native
Fabaceae	*Acacia verniciflua*	Native
Fabaceae	*Bossiaea buxifolia*	Native
Fabaceae	*Bossiaea sp.*	Native
Fabaceae	*Daviesia ulicifolia*	Native
Fabaceae	*Desmodium brachypodum*	Native
Fabaceae	*Desmodium varians*	Native
Fabaceae	*Glycine clandestina*	Native
Fabaceae	*Glycine tabacina*	Native
Fabaceae	*Podolobium ilicifolium*	Native
Fabaceae	*Swainsona galegifolia*	Native
Fabaceae	*Trifolium arvense*	Exotic
Fabaceae	*Trifolium repens*	Exotic
Fabaceae	*Trifolium sp.*	Exotic
Fabaceae	*Trifolium subterraneum*	Exotic
Geraniaceae	*Erodium botrys*	Exotic
Geraniaceae	*Erodium cicutarium*	Exotic
Geraniaceae	*Erodium crinitum*	Native
Geraniaceae	*Erodium moschatum*	Exotic
Goodeniaceae	*Goodenia hederacea*	Native
Goodeniaceae	*Goodenia hederacea subsp. Hederacea*	Native

Family	Scientific Name	Native / Exotic
Goodeniaceae	*Goodenia ovata*	Native
Haloragaceae	*Haloragis heterophylla*	Native
Hormiaceae	*Dianella revoluta*	Native
Juncaceae	*Juncus sp.*	Native/exotic
Juncaceae	*Juncus usitatus*	Native
Lamiaceae	*Ajuga australis*	Native
Lamiaceae	*Marrubium vulgare*	Exotic
Lamiaceae	*Mentha satureioides*	Native
Lamiaceae	*Stachys arvensis*	Exotic
Lauraceae	*Cassytha pubescens*	Native
Lomandraceae	*Lomandra confertifolia*	Native
Lomandraceae	*Lomandra filiformis*	Native
Lomandraceae	*Lomandra filiformis subsp. filiformis*	Native
Lomandraceae	*Lomandra glauca*	Native
Lomandraceae	*Lomandra multiflora*	Native
Loranthaceae	*Amyema miquelii*	Native
Loranthaceae	*Amyema miquelii*	Native
Loranthaceae	*Amyema sp.*	Native
Malvaceae	*Brachychiton populneus*	Native
Malvaceae	*Malva parviflora*	Exotic
Malvaceae	*Modiola caroliniana*	Exotic
Malvaceae	*Sida corrugata*	Native
Myrtaceae	*Angophora floribunda*	Native
Myrtaceae	*Corymbia trachyphloia*	Native
Myrtaceae	*Eucalyptus albens*	Native
Myrtaceae	*Eucalyptus blakelyi*	Native
Myrtaceae	*Eucalyptus bridgesiana*	Native
Myrtaceae	*Eucalyptus crebra*	Native
Myrtaceae	*Eucalyptus dealbata*	Native
Myrtaceae	*Eucalyptus dwyeri*	Native
Myrtaceae	*Eucalyptus fibrosa*	Native
Myrtaceae	*Eucalyptus melliodora*	Native
Myrtaceae	*Eucalyptus moluccana*	Native
Myrtaceae	*Eucalyptus punctata*	Native
Myrtaceae	*Eucalyptus rossii*	Native
Myrtaceae	*Eucalyptus sideroxylon*	Native
Myrtaceae	*Eucalyptus sparsifolia*	Native

Family	Scientific Name	Native / Exotic
Myrtaceae	*Kunzea ambigua*	Native
Myrtaceae	*Melaleuca erubescens*	Native
Myrtaceae	*Melaleuca uncinata*	Native/exotic
Myrtaceae	*Sannantha cunninghamii*	Native
Orchidaceae	*Orchidaceae sp.*	Native
Oxalidaceae	*Oxalis perennans*	Native
Oxalidaceae	*Oxalis sp.*	Native/exotic
Phyllanthaceae	*Poranthera corymbosa*	Native
Pittosporaceae	*Bursaria spinosa*	Native
Plantaginaceae	*Plantago lanceolata*	Exotic
Plantaginaceae	*Plantago sp.*	Native/exotic
Poaceae	*Aira sp.*	Exotic
Poaceae	*Aristida ramosa*	Native
Poaceae	*Aristida vagans*	Native
Poaceae	*Arundinella nepalensis*	Native
Poaceae	*Austrostipa densiflora*	Native
Poaceae	*Austrostipa scabra*	Native
Poaceae	*Austrostipa sp.*	Native
Poaceae	*Bothriochloa macra*	Native
Poaceae	*Bothriochloa sp.*	Native
Poaceae	*Bromus hordeaceus*	Exotic
Poaceae	*Cenchrus clandestinus*	Exotic
Poaceae	*Chloris gayana*	Exotic
Poaceae	*Chloris truncata*	Native
Poaceae	*Cleistochloa rigida*	Native
Poaceae	*Cymbopogon refractus*	Native
Poaceae	*Cynodon dactylon*	Native
Poaceae	*Dichelachne sp.*	Native
Poaceae	*Digitaria brownii*	Native
Poaceae	*Digitaria eriantha*	Exotic
Poaceae	*Digitaria eriantha*	Exotic
Poaceae	*Digitaria parviflora*	Native
Poaceae	*Digitaria sp.*	Native/exotic
Poaceae	*Echinopogon sp.*	Native
Poaceae	*Eleusine tristachya*	Exotic
Poaceae	*Enneapogon sp.*	Native
Poaceae	*Eragrostis brownii*	Native

Family	Scientific Name	Native / Exotic
Poaceae	*Eragrostis cilianensis*	Exotic
Poaceae	*Eragrostis curvula*	Exotic
Poaceae	*Eragrostis leptostachya*	Native
Poaceae	*Eragrostis sp.*	Native/exotic
Poaceae	*Microlaena stipoides*	Native
Poaceae	*Panicum effusum*	Native
Poaceae	*Paspalum dilatatum*	Exotic
Poaceae	*Paspalum dilatatum*	Exotic
Poaceae	*Phalaris aquatica*	Exotic
Poaceae	*Phalaris sp.*	Exotic
Poaceae	*Poa sp.*	Native/exotic
Poaceae	*Rytidosperma pallidum*	Native
Poaceae	*Rytidosperma racemosum*	Native
Poaceae	*Rytidosperma sp.*	Native
Poaceae	*Setaria parviflora*	Exotic
Poaceae	*Setaria sp.*	Exotic
Poaceae	*Sporobolus creber*	Native
Poaceae	*Themeda triandra*	Native
Poaceae	*Vulpia sp.*	Exotic
Polygonaceae	*Acetosella vulgaris*	Exotic
Polygonaceae	*Rumex brownii*	Native
Portulacaceae	*Portulaca oleracea*	Native
Primulaceae	*Lysimachia arvensis*	Exotic
Proteaceae	*Hakea dactyloides*	Native
Proteaceae	*Persoonia curvifolia*	Native
Proteaceae	*Persoonia linearis*	Native
Pteridaceae	*Cheilanthes distans*	Native
Pteridaceae	*Cheilanthes sieberi*	Native
Ranunculaceae	*Clematis aristata*	Native
Ranunculaceae	*Clematis glycinoides*	Native
Rosaceae	*Acaena ovina*	Native
Rosaceae	*Acaena sp.*	Native
Rosaceae	*Rosa rubiginosa*	Exotic
Rosaceae	*Rubus fruticosus species aggregate*	Exotic
Rubiaceae	*Opercularia diphylla*	Native
Rubiaceae	*Opercularia hispida*	Native
Rubiaceae	*Opercularia sp.*	Native

Family	Scientific Name	Native / Exotic
Rubiaceae	*Pomax umbellata*	Native
Rubiaceae	*Richardia stellaris*	Exotic
Rubioideae	*Galium sp.*	Native/exotic
Rutaceae	*Phebalium squamulosum*	Native
Rutaceae	*Phyllanthus hirtellus*	Native
Santalaceae	*Exocarpos cupressiformis*	Native
Santalaceae	*Exocarpos strictus*	Native
Sapindaceae	*Dodonaea sp.*	Native
Sapindaceae	*Dodonaea viscosa*	Native
Sapindaceae	*Dodonaea triangularis*	Native
Scrophulariaceae	*Verbascum virgatum*	Exotic
Scrophulariaceae	*Veronica plebeia*	Native
Solanaceae	*Solanum prinophyllum*	Native
Solanaceae	*Solanum sp.*	Native/exotic
Stackhousiaceae	*Stackhousia viminea*	Native
Thymelaeaceae	*Pimelea linifolia*	Native
Urticaceae	*Urtica incisa*	Native
Verbenaceae	*Verbena bonariensis*	Exotic
Xanthorrhoeaceae	*Xanthorrhoea johnsonii*	Native
Zamiaceae	*Macrozamia secunda*	Native
Anthericaceae	*Laxmannia gracilis*	Native

Appendix I – Fauna species list (Summer, Winter and Spring 2019)

Species name	Common name	BC Act	EPBC Act
Birds			
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		
Acanthiza lineata	Striated Thornbill		
Acanthiza nana	Yellow Thornbill		
Acanthiza pusilla	Brown Thornbill		
Acanthiza reguloides	Buff-rumped Thornbill		
Acanthorhynchus tenuirostris	Eastern Spinebill		
Aegotheles cristatus	Australian Owlet-nightjar		
Alectura lathami	Australian Brush-turkey		
Alisterus scapularis	Australian King-Parrot		
Anas superciliosa	Pacific black duck		
Anthochaera carunculata	Red Wattlebird		
Anthus novaeseelandiae	Australasian Pipit		
Aphelocephala leucopsis	Southern Whiteface		
Aquila audax	Wedge-tailed Eagle		
Artamus cyanopterus	Dusky Woodswallow	V	
Artamus superciliosus	White-browed Woodswallow		
Cacatua galerita	Sulphur-crested Cockatoo		
Cacomantis variolosus	Brush Cuckoo		
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	
Ceyx azureus	Azure Kingfisher		
Chalcites osculans	Black-eared cuckoo		
Chenonetta jubata	Australian Wood Duck		
Circus assimilis	Spotted Harrier		
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	
Colluricincla harmonica	Grey Shrike-thrush		
Coracina novaehollandiae	Black-faced Cuckoo-shrike		
Coracina tenuirostris	Cicadabird		
Corcorax melanorhamphos	White-winged Chough		
Cormobates leucophaea	White-throated Treecreeper		
Corvus coronoides	Australian Raven		
Cracticus nigrogularis	Pied Butcherbird		
Cracticus tibicen	Australian Magpie		

Species name	Common name	BC Act	EPBC Act
Cracticus torquatus	Grey Butcherbird		
Dacelo novaeguineae	Laughing Kookaburra		
Daphoenositta chrysoptera	Varied Sittella	V	
Dicaeum hirundinaceum	Mistletoe bird		
Dromaius novaehollandiae	Emu		
Egretta novaehollandiae	White-faced Heron		
Eolophus roseicapillus	Galah		
Eopsaltria australis	Eastern Yellow Robin		
Eurystomus orientalis	Dollarbird		
Falco berigora	Brown Falcon		
Falco cenchroides	Nankeen Kestrel		
Falco longipennis	Australian Hobby		
Falcunculus frontatus	Crested Shrike-tit		
Geopelia humeralis	Bar-shouldered Dove		
Geopelia placida	Peaceful dove		
Gerygone albogularis	White-throated Gerygone		
Glossopsitta concinna	Musk lorikeet		
Glossopsitta pusilla	Little Lorikeet	V	
Grallina cyanoleuca	Magpie-lark		
Grantiella picta	Painted honeyeater	V	V
Hirundo neoxena	Welcome Swallow		
Lalage sueurii	White-winged Triller		
Leucosarcia melanoleuca	Wonga Pigeon		
Lichenostomus chrysops	Yellow-faced Honeyeater		
Lichenostomus fuscus	Fuscous honeyeater		
Lichenostomus leucotis	White-eared Honeyeater		
Lichenostomus melanops	Yellow-tufted Honeyeater		
Lichenostomus penicillatus	White-plumed Honeyeater		
Lichmera indistincta	Brown Honeyeater		
Macropygia amboinensis	Brown Cuckoo-dove		
Malurus cyaneus	Superb Fairy-wren		
Malurus lamberti	Variegated Fairy-wren		
Manorina melanocephala	Noisy Miner		
Manorina melanophrys	Bell Miner		
Melanodryas cucullata	Hooded Robin	V	
Melithreptus brevirostris	Brown-headed Honeyeater		

Species name	Common name	BC Act	EPBC Act
Melithreptus lunatus	White-naped Honeyeater		
Melopsittacus undulatus	Budgerigar		
Menura novaehollandiae	Superb Lyrebird		
Merops ornatus	Rainbow Bee-eater		
Microeca fascinans	Jacky Winter		
Myiagra inquieta	Restless Flycatcher		
Myzomela sanguinolenta	Scarlet Honeyeater		
Neochmia temporalis	Red-browed Finch		
Neophema chrysostoma	Blue-winged Parrot		
Ninox novaeseelandiae	Southern Boobook		
Ninox strenua	Powerful Owl	V	
Ocyphaps lophotes	Crested Pigeon		
Origma solitaria	Rock warbler		
Oriolus sagittatus	Olive-backed Oriole		
Pachycephala pectoralis	Golden Whistler		
Pachycephala rufiventris	Rufous Whistler		
Pardalotus punctatus	Spotted Pardalote		
Pardalotus striata	Striated Pardalote		
Petrochelidon nigricans	Tree Martin		
Petroica boodang	Scarlet robin	V	
Petroica goodenovii	Red-capped Robin		
Petroica rosea	Rose robin		
Phalacrocorax carbo	Great Cormorant		
Phaps chalcoptera	Common Bronzewing		
Philemon corniculatus	Noisy Friarbird		
Platycercus elegans	Crimson Rosella		
Platycercus eximius	Eastern Rosella		
Plectorhyncha lanceolata	Striped Honeyeater		
Pomatostomus superciliosus	White-browed Babbler		
Psephotus haematonotus	Red-rumped Parrot		
Psophodes olivaceus	Eastern Whipbird		
Ptilonorhynchus violaceus	Satin Bowerbird		
Pycnoptilus floccosus	Pilot bird		
Pyrrholaemus sagittatus	Speckled Warbler	V	
Rhipidura albiscapa	Grey Fantail		
Rhipidura leucophrys	Willy Wagtail		

Species name	Common name	BC Act	EPBC Act
Sericornis frontalis	White-browed Scrub wren		
Smicrornis brevirostris	Weebill		
Stagonopleura guttata	Diamond Firetail	V	
Strepera graculina	Pied Currawong		
Sturnus vulgaris	Common Starling		
Tachybaptus novaehollandiae	Australasian Grebe		
Taeniopygia bichenovii	Double-barred Finch		
Todiramphus sanctus	Sacred Kingfisher		
Trichoglossus moluccanus	Rainbow lorikeet		
Turnix varius	Painted Button Quail		
Vanellus miles	Masked Lapwing		
Vanellus tricolor	Banded lapwing		
Zosterops lateralis	Silvereye		
Amphibian			
Limnodynastes dumerilii	Eastern Banjo Frog		
Reptiles			
Amphibolurus muricatus	Jacky Lizard		
Carlia tetradactyla	Southern Rainbow Skink		
Ctenotus taeniolatus	Copper-tailed Skink		
Demansia psammophis	Yellow-faced Whipsnake		
Furina diadema	Red-naped Snake		
Lygisaurus foliorum	Litter Skink		
Nebulifera robusta	Velvet Gecko		
Pogona barbata	Bearded Dragon		
Pseudechis porphyriacus	Red Bellied Black Snake		
Pseudonaja textilis	Eastern Brown Snake		
Underwoodisaurus milii	Barking Gecko		
Varanus varius	Lace Monitor		
Microbat			
Austronomus australis	White-Striped Free-tailed Bat		
***Chalinolobus dwyeri**[1]*	**Large-eared Pied Bat**	V	V
Chalinolobus gouldii	Gould's Wattled Bat		
Chalinolobus morio	Chocolate Wattled Bat		
Miniopterus orianae oceanensis*	**Large Bentwing Bat**	V	
Rhinolophus megaphyllus	Eastern Horseshoe Bat		
Scotorepens balstoni	Inland Broad-nosed Bat		

Species name	Common name	BC Act	EPBC Act
Vespadelus darlingtoni	Large Forest Bat		
Vespadelus troughtoni*	**Eastern Cave Bat**	V	
Vespadelus vulturnus	Little Forest Bat		

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Review of BMP Management Schedule for 2019

Management Strategy	Objectives	2019	Comments
Cultural Heritage Management	Identification of cultural heritage sites within the Biodiversity Offset Areas to avoid potential harm	• Undertake Due Diligence cultural heritage surveys in accordance with Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW to identify cultural heritage sites if works are required.	Not Triggered in 2019. No disturbance activities during the 2019 reporting period.
	Cultural heritage items within the approved disturbance area, ECAs, Regeneration and Rehabilitation Areas are managed in accordance with the WCPL ACHMP (within DA boundaries) and Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW for areas elsewhere	• Continue implementation of WCPLs ACHMP, Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW and WCPLs GDP Process	Due diligence surveys completed in 2019: • Within Stage 1 of ECA_B for Stage 1 Tree Planting along the banks of Wilpinjong Creek. • Within ECA A along Cumbo Creek for Cumbo Creek Tree Planting
Fencing, Gates and Signage	Clearly delineate all Biodiversity Offset Areas, ECAs and Regeneration Areas	• Identify appropriate locations for signage	Opportunistic and quarterly Inspections ongoing throughout the 2019 reporting period. All stock excluded. Repair of fences and gates ongoing as required (not triggered in 2019).
	Prevent unauthorised human access and exclude livestock from areas of native regeneration (unless being used as within management program i.e. crash grazing)to all Management Domains	• Identify failed fences and gates • Develop a fence repair and replacement program • Undertake annual and opportunistic security inspections (fences, gates and signage). Schedule and undertake necessary repairs	
	Access to the Management Domains is retained for maintenance and safety purposes	• Identify and map all access gates	
Access Tracks	Reduce and rehabilitate unnecessary access tracks in all Biodiversity Offset Areas, ECAs and Regeneration Areas	• Identify and map all unnecessary access tracks	Inspections ongoing throughout the 2019 reporting period. Repair and maintenance of access tracks ongoing as required (not triggered in 2019). Bushfire management plan review completed in 2018. Finalising of the revised BFMP occurred in early 2019.
	Provide safe, unimpeded access for monitoring and maintenance, bushfire management, and asset protection in all Biodiversity Offset Areas, ECAs and Regeneration Areas	• Identify and map all access tracks required for safe and ongoing access, including tracks suitable for a CAT 1 tanker • Develop a repair and maintenance program for existing tracks that are proposed to remain • Seek relevant authorisation to enable construction of new access tracks (as required)	

Management Strategy	Objectives	2019	Comments
Waste Management	All Biodiversity Offset Areas, ECAs and Regeneration Areas are free of waste, disused buildings and redundant farm equipment	• Undertake a detailed waste inspection for the presence of dumped waste, disused buildings and redundant farm equipment • Continue removal of all identified waste, disused buildings and redundant farm equipment • Rehabilitation of disused building sites • Undertake annual and opportunistic waste inspections. Schedule and commission removal of all additional waste	Inspections ongoing throughout the 2019 reporting period. Removal of building wastes was not triggered in 2019. Opportunistic removal of waste to continue in 2020.
Erosion, Sedimentation and Soil Management	Erosion, sediment or soil (ie. Salinity) risks are identified and mapped in all Biodiversity Offset Areas, ECAs and Regeneration Areas	• Undertake a detailed inspection of all Biodiversity Offset Areas, ECAs and Regeneration Areas and accurately map areas that present an erosion, sediment or soil (ie. Salinity) risk	Inspections ongoing throughout the 2019 reporting period, which included use of LFA in accordance with the BMP.
	A risk based monitoring and management plan is developed for erosion, sediment and soil risks in all Biodiversity Offset Areas, ECAs and Regeneration Areas	• Undertake a detailed inspection of all Biodiversity Offset Areas, ECAs and Regeneration Areas and accurately map areas that present an erosion, sediment or soil (i.e. Salinity) risk	
Grazing and Stock Management	Exclude livestock from areas of native regeneration in all Biodiversity Offset Areas, ECAs and Regeneration Areas (unless being used as within management program)	• Repair, replace or install new livestock exclusion fences • Undertake opportunistic and annual inspections. Schedule and undertake necessary repairs	Inspections ongoing throughout the 2019 reporting period. All stock excluded. Leasee inspections of fences prior to stocking adjacent to ECAs and Regen Areas. Focus on implementation of BVT performance and completion for 2019. Livestock unlikely to be use due to the revised requirement for native vegetation as opposed to previous agricultural land use.
	Consider livestock as a rehabilitation management tool	• Review rehabilitation performance towards completion criteria • If deemed appropriate, seek technical advice regarding the use of livestock as a rehabilitation management tool	
Seed Collection and Propagation	All seed collectors are appropriately qualified and trained	• Confirm training records for engaged seed collectors	

Management Strategy	Objectives	2019	Comments
	Local species are included in revegetation and rehabilitation seed mixes	• Identify available seed species • Species collected to align with BVT species list and as required for site rehabilitation	Hunter Ecological confirmed diagnostic indicator species required BVTs in 2018/2019. Scope of works developed for seed collection with regards to BVT seed mix confirmation. Tender prepared and contract executed for seed collection in 2019.
	Locally sourced seed is available for revegetation and rehabilitation works within all Management Domains	• Implement Seed Collection Program	
Habitat Augmentation	Habitat augmentation opportunities are identified and assessed	• Implement Habitat Augmentation Procedure and recommendations where applicable	The BMP monitoring includes assessment of native vegetation and habitat complexity. The assessments are annual and reviewed accordingly. WCPL developed a *Habitat Augmentation Procedure* which was implemented in 2019. Works included the importation of woody debris onto rehabilitation sites along with the installation of 100 nesting boxes in ECAs and Regen Areas adjacent to rehabilitation and mining areas.
Revegetation and Regeneration	Increase overall native plant species richness in ECAs, Regeneration and Rehabilitation Areas	**ECA-B** Revegetation of local native over-storey and shrub species within poor condition areas **Regeneration Area 1** Opportunistic supplementary tree planting **Regeneration Area 9** Opportunistic supplementary tree planting	Stage 1 of ECA_B completed in 2019 with 1400 trees planted along a section of Wilpinjong Creek.
Weed Management	Noxious and environmental weeds are identified and mapped in all Biodiversity Offset Areas, ECAs and Regeneration Areas	• Undertake a detailed inspection of all Biodiversity Offset Areas, ECAs and Regeneration Areas and accurately map (GIS) noxious and environmental weeds	Weed spraying was undertaken primarily on off lease Peabody owned landholdings in (refer to 2019 Spray Map – Appendix 5).

Management Strategy	Objectives	2019	Comments
	A risk based weed management program is developed for all Biodiversity Offset Areas, ECAs, Regeneration and Rehabilitation Management Domains	• Implement weed management program • Undertake weed inspections • Schedule and undertake necessary weed treatment	In 2019 target weed spraying was completed based on internal and MWRC inspections from previous seasons. Leasees across the broader company landholdings also undertake ongoing weed management.
	Reduced presence of noxious and environmental weeds	• Implement management measures for high risk areas identified from weed inspection Specific Actions include: • Continued Control of St Johns Wort, Blackberry and Juncus acutus (Spiny Rush) along Cumbo Creek within ECA-A and Regeneration Area 2 • Continued Control of St Johns Wort, Blackberry and Juncus acutus (Spiny Rush) along Wilpinjong Creek within ECA-B and Regeneration Areas 1, 5 and 9 • Broad-leaf weed treatment in poor condition native pastures within ECA-B, and Regeneration Areas 1 and 9 • Follow-up control of Blackberry and tree-of-heaven within Regeneration Area 7 • Implement control of St Johns Wort in 'pre-strip' areas 2 years ahead of mining	
Vertebrate Pest Management	Control vertebrate pest species likely to pose a threat to the Biodiversity Offset Areas, ECAs and Regeneration and Rehabilitation Areas	• Consult with LLS in developing a vertebrate pest management program • Implement management measures for high risk areas identified in the detailed inspection	In 2019, targeted pest species management included pest monitoring, feral pig trapping, fox and wild dog control in Spring and Autumn in conjunction with the local wild dog group. Aerial dog bating and trapping campaign with LLS in 2019. This program was undertaken in consultation with Local Land Services (LLS) as a result of know wild dog activity in the local area. Lessees across the broader company landholdings also undertake ongoing vertebrate pest management.

Management Strategy	Objectives	2019	Comments
Bushfire Management	Maintain the environmental and habitat features of the Biodiversity Offset Areas, ECAs and Regeneration and Rehabilitation Areas	• In consultation with the NSW RFS, review and update the WCPL Bushfire Management to include management controls for all Management Domains • Identify the need for Asset protection Zones (APZ) for the Biodiversity Offset Areas, ECAs and Regeneration and Rehabilitation Areas • Establish APZ's as required	Bushfire management plan review completed in 2018. Finalising of the revised BFMP occurred in early 2019.
Biodiversity Monitoring	Monitor biodiversity within the Biodiversity Offset Areas, ECAs and Regeneration and Rehabilitation Areas to assess progress against interim, performance and completion criteria	• Implement Biodiversity Monitoring Program and analyse results against interim, performance and completion criteria and undertake corrective actions where required.	The BMP monitoring program was implemented throughout 2019. Assessment includes analysis of native vegetation and habitat complexity as prescribed within the BMP.
Inspections and Document Control	Ensure implemented management actions are successful in progressing towards completion criteria	• Undertake and document Inspections	This Annual Review.
	All actions, monitoring data and performance outcomes are documented and reported	• Document all actions, monitoring data and performance outcomes	
Management of Biodiversity Offsets 1-5	Manage Biodiversity Offset Areas 1-5 and facilitate their transfer to the National Parks Estate.	• Undertake general weed and pest control.	In 2019, targeted pest species management included pest monitoring, feral pig trapping, fox and wild dog control in Spring and Autumn in conjunction with the local wild dog group. Aerial dog bating and trapping campaign with LLS in 2019. This program was undertaken in consultation with Local Land Services (LLS) as a result of know wild dog activity in the local area. Weed spraying was undertaken primarily on off lease Peabody owned landholdings in (refer to 2019 Spray Map – Appendix 5).
Early establishment of Regent Honeyeater habitat in available areas	Establish Regent Honeyeater habitat within existing mine rehabilitation areas where rehabilitation to date has focussed on the establishment of productive pasture for grazing.	• Develop suitable rehabilitation performance and completion criteria for the establishment of Regent Honeyeater habitat in consultation with OEH.	BVT performance and completion criteria relevant to the rehabilitation areas were confirmed by the DPIE in April 2019 in accordance with Schedule 3, Condition 37 of the Development Consent SSD-6764.

Management Strategy	Objectives	2019	Comments
Rehabilitation of the Mine site to recognised habitat and ecosystem values	Establish recognised BVTs and Regent Honeyeater habitat in the Rehabilitation Areas.	• Develop suitable BVT performance and completion criteria in consultation with OEH.	The BMP was comprehensively updated in 2019 as required to reflect the new criteria
Propagation of *Ozothamnus tesselatus*	Successfully propagate *Ozothamnus tesselatus* in suitable Mine site rehabilitation areas.	• Collect seeds of the threatened *Ozothamnus tesselatus* from the known populations within the open cut extension and infrastructure areas and throughout the Biodiversity Offset Areas.	Collection of seeds for *Ozothamnus tessalatus* was initially undertaken in 2018. Propagation trials, viability trials and collection continued in 2019.
Revegetation works along Cumbo and Wilpinjong Creeks	Establish revegetation on sections of Cumbo and Wilpinjong Creeks in WCPL and Peabody ownership.	• Develop a works program detailing the revegetation activities to be conducted along Cumbo and Wilpinjong Creeks.	Tree planting works programs developed for Regen Areas 1,2,4,5,9 and ECAs with tree planting to occur in 2020.

Suite 1, Level 1
79 Market Street
Mudgee NSW 2850
t: (02) 4302 1234

11 September 2019

Our ref: 13972

Wilpinjong Coal Pty Ltd
1434 Ulan-Wollar Road
Wilpinjong NSW 2850

Attention: Josh Frappell

Dear Josh,

Re: WCPL Stage 1 Rehabilitation Identification

Eco Logical Australia (ELA) was engaged by Wilpinjong Coal Pty Limited (WCPL) to undertake an assessment within Areas 6 to 9 of existing Stage 1 Rehabilitation. The survey aimed to identify and record midstorey and overstorey species characteristic of the following target Biometric Vegetation Types (BVTs) within each rehabilitation area (Table 1). The location and area of each BVT can be seen within **Appendix A**.

Table 1: BVTs within each of the rehabilitation areas

Area	BVT
Area 6	HU732 - Yellow Box Grassy Woodland
Area 7	HU732 - Yellow Box Grassy Woodland
Area 8	HHU697 - Mugga Ironbark Open Forest HU732 - Yellow Box Grassy Woodland
Area 9	HU697 - Mugga Ironbark Open Forest HU732 - Yellow Box Grassy Woodland HU824 - White Box Shrubby Woodland.

Upper stratum and mid stratum species that are suitable for each BVT are seen within Table 2.

Table 2: Suitable upper and Mid Stratum species for each BVT

BVT	Upper Stratum	Mid Stratum
HU697 - Mugga Ironbark Open Forest	• *Eucalyptus sideroxylon*	• *Leucopogon attenuates* • *Brachyloma daphnoides subsp. daphnoides* • *Cassinia arcuata* • *Melichrus urceolatus* • *Macrozamia secunda*

BVT	Upper Stratum	Mid Stratum
		• *Platysace ericoides* • *Astroloma humifusum* • *Phyllanthus hirtellus* • *Hibbertia obtusifolia* • *Xanthorrhoea australis* • *Grevillea sericea* • *Cassinia laevis* • *Allocasuarina gymnanthera* • *Acacia spectabilis* • *Acacia gladiiformis*
HU732 - Yellow Box Grassy Woodland	• *Eucalyptus melliodora* • *Angophora floribunda* • *Brachychiton populneus subsp. populneus* • *Casuarina cristata*	• *Pimelea curviflora var. curviflora* • *Acacia implexa* • *Acacia decora* • *Solanum cinereum* • *Acacia caesiella* • *Cassinia arcuate* • *Geijera parviflora* • *Atriplex semibaccata;*
HU824 - White Box Shrubby Woodland	• *Eucalyptus albens*	• *Cassinia arcuata*

METHOD

The survey was undertaken on 26, 28, 29 and 30 August 2019 by ELA ecologists Tom Kelly and Kate Maslen, with assistance from WCPL. An initial inspection of all four rehabilitation areas was completed to assess the suitability of overstorey and midstorey species to the nominated BVT for each rehabilitation area. Upon completion of the inspection, it was concluded that Area 7 and 9 consisted of suitable densities of desired species, whilst Area 6 and 8 consisted of very low densities of desired species. The results of the initial inspection guided the following methodologies for each area:

- Area 7
  - Each individual plant that was appropriate for HU732 (see Table 3) was recorded using a handheld GPS and flagged with blue and white flagging tape. The remaining trees and shrubs of unsuitable species without flagging tape are to be removed.
- Area 9
  - Each individual plant that was appropriate for BVTs HU732, HU697 and HU824 (see Table 3) was recorded using a handheld GPS and flagged with blue and white flagging tape within their respective designated areas. The remaining trees and shrubs of unsuitable species without flagging tape are to be removed.
- Area 6 and Area 8
  - As area 6 and 8 consisted of very low densities of desired species, it was determed that within these areas, *Eucalyptus albens* (White Box) will be translocated to other rehabilitation areas nominated for rehabilitation to White Box Srubby Woodland (HU824).
  - White Box located along the edge of the rehabilitation area and of a suitable size and structure for translocation was recorded using a handheld GPS and flagged with blue and white flagging tape.

RESULTS AND DISCUSSION

The survey identified and recorded the following species presented within Table 3.

Table 3: Suitable species present within each area

Rehabilitation area	Scientific Name	Common Name	Number of individuals
Area 6	*Eucalyptus albens*	White Box	62
Area 7	*Acacia decora*	Western Silver Wattle	1389
	Acacia implexa	Hickory Wattle	63
	Cassinia arcuata	Sifton Bush	16
	Eucalyptus melliodora	Yellow Box	1945
Area 8	*Eucalyptus albens*	White Box	122
Area 9	*Acacia decora*	Western Silver Wattle	27
	Acacia implexa	Hickory Wattle	7
	Cassinia arcuata	Sifton Bush	1
	Eucalyptus albens	White Box	120
	Eucalyptus melliodora	Yellow Box	105
	Eucalyptus sideroxylon	Mugga Ironbark	14

Table 4 below provides the approximate densities of target overstorey species present within Area 7 and 9, along with approximate overstorey stem densities (stems/ha) typical of their respective target BVTs. As displayed, both Area 7 and 9 contain overstorey stem densities of characteristic species well in excess of the typical densities of their respective target BVTs. This data supports the suitability of both Area 7 and 9 as candidate areas for further progression towards their target BVTs.

Table 4: Approximate overstorey stem densities for respective target BVTs and recorded overstorey stem densities in rehabilitation Area 7 and 9

Rehabilitation area	BVT	Typical overstorey density (stems/ha) for target BVT	Recorded overstorey density (stems/ha)
Area 7	HU732 - Yellow Box Grassy Woodland	30-40	285
Area 9	HU824 - White Box Shrubby Woodland	60-80	101
	HU732 - Yellow Box Grassy Woodland	30-40	135
	HU697 - Mugga Ironbark Open Forest	60-80	140

A list of all data points in electronic format (ArcGIS shapefiles) will be provided to WCPL.

RECOMMENDATIONS AND CONCLUSIONS

Within both Area 7 and 9, manual tree removal of non-target overstorey and midstorey species using chainsaws or other small machinery is recommended to minimise impact to adjacent target species, as opposed to the use of larger machinery such as bulldozers and/or excavators. It is recommended that

the removal of non-target species from these areas be undertaken as soon as possible, as flagging tape is likely to deteriorate over time.

The north-west section of Area 9 is dominated by Yellow Box, Western Silver Wattle and Hickory Wattle and is suitable for bulk translocation into adjacent rehabilitation areas nominated to HU732.

Prior to translocation of White Box from Areas 6 and 8, the trees should be watered 24-48 hours prior to translocation. White Box trees with abundant foliage can be trimmed back to reduce stress post-translocation and optimise the potential for successful re-establishment. As the remaining vegetation within Areas 6 and 8 is well established, a staged approach to removing this vegetation should be considered to ensure the stability of the area whilst target BVT species are introduced, as well as provide continued habitat for fauna. Large trees greater than 10 cm in diameter can also be utilised as large-woody debris.

A high diversity of tree and shrub species were encountered during Stage 1 of the rehabilitation tree assessment relative to the rehabilitation seeding list. This highlights the need for strict quality control of seed procurement to ensure that only characteristic species from the target BVTs are seeded.

If you have any questions or require further information or advice, please do not hesitate to contact me.

Regards,

Tom Kelly
Ecologist

Attachment A – Stage 1 Rehabilitation Area maps

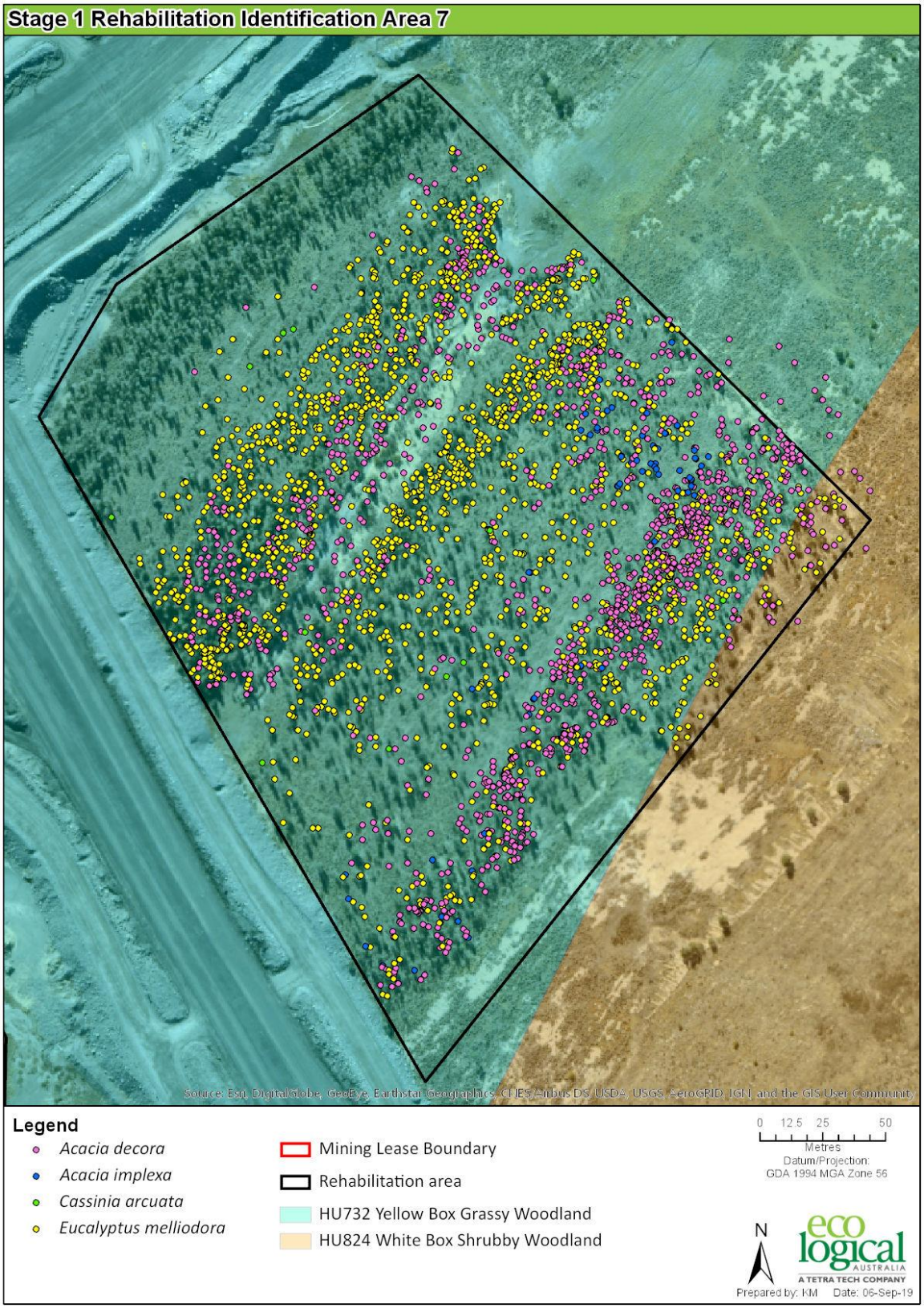

Figure 1: Species located within Area 7, that are suitable for BVT HU732

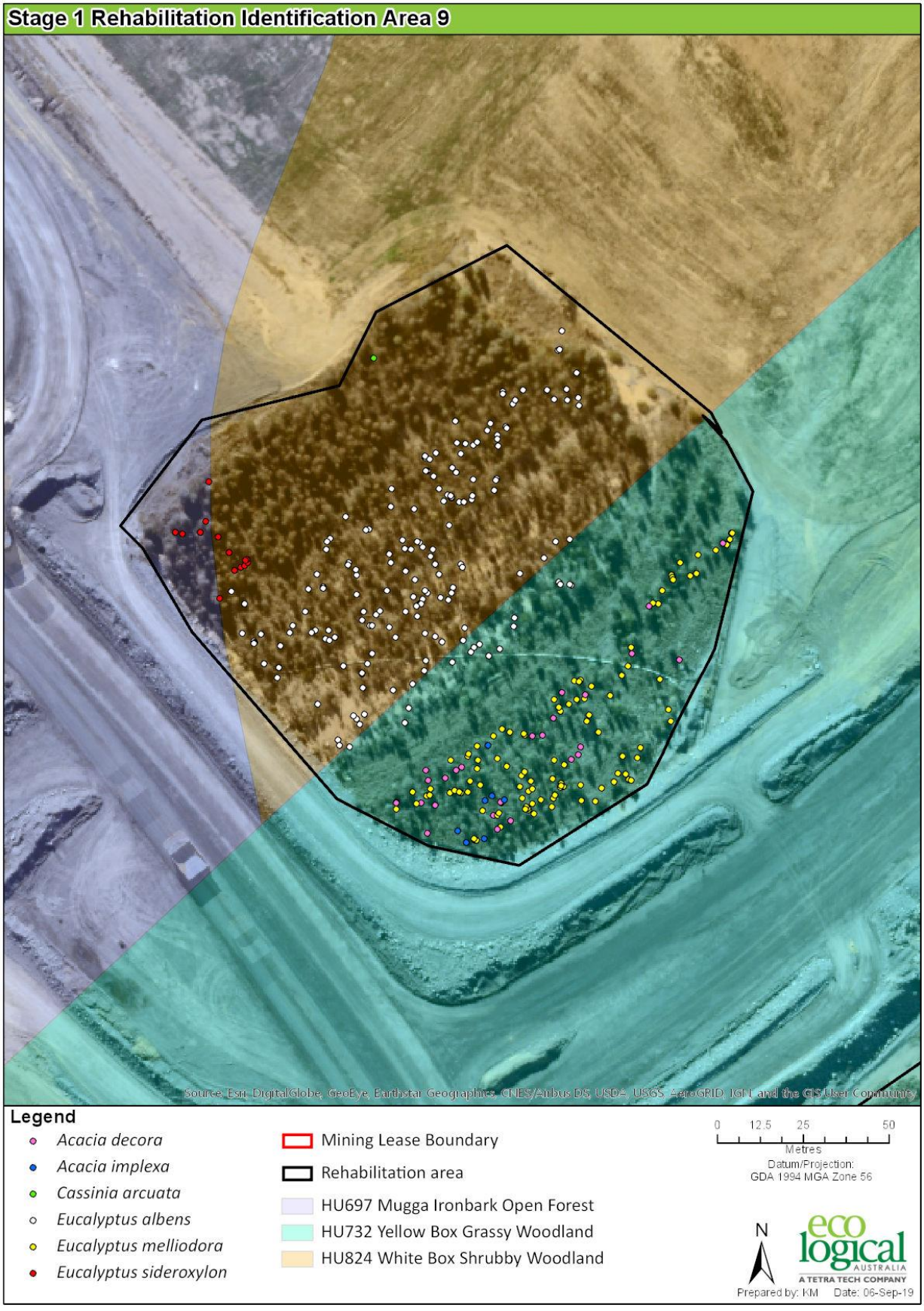

Figure 2: Species that are suited for BVT HU697, HU72 and HU824, respectively

Figure 3: *Eucalyptus albens* located within Area 6, that are suitable for translocation

Figure 4: *Eucalyptus albens* located within Area 8, that are suitable for translocation

Wilpinjong Coal Mine
2019 Channel Stability Monitoring

Wilpinjong Coal Pty Ltd

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1300 646 131
www.ecoaus.com.au

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Template 2.8.1

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Abbreviations

Abbreviation	Description
BEHI	Bank Erosion Hazard Index
CSM	Channel Stability Monitoring
EIS	Environmental Impact Statement
ELA	Eco Logical Australia
ML	Mining Lease
IFD	Intensity-Frequency-Duration
WCPL	Wilpinjong Coal Pty Ltd

Summary of key findings

Channel stability monitoring was undertaken in 2019 to provide an assessment of overall riparian stability and health within the Wilpinjong Coal Mine and surrounds. Fifty-nine (59) permanent survey sites were monitored along Wilpinjong and Cumbo Creeks. Monitoring assessed channel stability indicators including bank height and angle, streambank protection and riparian vegetation cover. Channel Stability ratings at monitoring sites along Wilpinjong Creek ranged from Moderately Unstable to Highly Stable, and Stable to Highly Stable along Cumbo Creek.

Comparison of monitoring data from 2016 through to 2019 found that the stability rating has either improved or remained constant for most monitoring sites (53 of 59) across both Wilpinjong and Cumbo Creeks. This reflects the overall stable nature of both creeks in what has been a prolonged dry period. Sites with a decline in channel stability between 2018 and 2019 are related to reduced vegetation cover, particularly of instream macrophytes. This reduction has been observed both upstream and downstream of Wilpinjong Coal Mine and is also related to the ongoing prolonged dry period.

Channel stability issues evident within Wilpinjong and Cumbo creeks relate primarily to both historic and existing agricultural practices, including vegetation clearing and stock access to the riparian zone.

Revegetation and remediation works have commenced along Wilpinjong Creek, with further works planned for both Wilpinjong and Cumbo creeks in 2020. Areas experiencing lateral erosion, including designated Erosion points, should be prioritised for revegetation and remediation works.

1. Introduction

1.1 Background

Eco Logical Australia (ELA) was engaged by Wilpinjong Coal Pty Ltd (WCPL) to undertake annual channel stability monitoring (CSM) along Wilpinjong and Cumbo Creeks. CSM is required to satisfy Schedule 3, Condition 32 of WCPL's Project Approval (05-0021), and the CSM criteria detailed in Appendix 2 of the Wilpinjong Water Management Plan (WCPL 2017).

1.2 Regional overview

The Wilpinjong Coal Mine (WCM) is located in the Mid Western Regional Council Local Government Area, approximately 45 km north-east of Mudgee. The mine is owned and operated by WCPL, a wholly owned subsidiary of Peabody Energy Australia.

WCM is located at the headwaters of the Goulburn River which is a major tributary of the Hunter River catchment. Wilpinjong Creek is the main drainage channel within the WCM. It is an intermittent creek with a narrow floodplain that has a history of cattle grazing. The northern edge of the floodplain is bordered by the sandstone escarpments of Goulburn River National Park (NP). Wilpinjong Creek has three coal mines in its catchment, Moolarben, Ulan, and Wilpinjong, with the latter positioned furthest downstream. WCPL discharges water into Wilpinjong Creek, treated by reverse osmosis, at a licensed discharge point (EPL24) directly adjacent to WCM.

Cumbo Creek flows north through land managed by WCPL, passing between Pit 3, Pit 7 and Pit 4, before joining Wilpinjong Creek north of the eastern pit area. Wilpinjong Creek continues to flow east, for approximately 4.5 km downstream where it joins Wollar Creek, which continues another 13 km through the Goulburn River NP before entering the Goulburn River.

1.3 Previous channel stability assessments

A baseline channel stability assessment of Wilpinjong and Cumbo Creeks was undertaken in 2005 as part of the Environmental Impact Statement (EIS) for the Wilpinjong Coal Project (WCPL 2005) to characterise the existing condition of the Wilpinjong and Cumbo creek stream channels prior to mining. The Wilpinjong Creek survey included 49 sites and extended 12.5 km from the upstream gauging station to the confluence with Wollar Creek to the east. The Cumbo Creek survey included 10 sites and extended 3 km from the southern boundary of the Mining Lease (ML) 1573 north to the confluence with Wilpinjong Creek.

The baseline surveys concluded both Wilpinjong and Cumbo Creeks have been affected by pre-mining land management practices dominated by sheep and cattle grazing. These land management practices involved the clearing of riparian vegetation on both creeks to maximise grazing areas and stock access to drinking water. The clearing of this vegetation is assumed to have contributed significantly to bank instability. Disturbance from burrowing animals, both native (e.g. *Vombatus ursinus* (Common Wombat)) and introduced (e.g. *Oryctolagus cuniculus* (European Rabbit)), is also likely to have contributed to this instability.

Subsequent annual CSM has been undertaken in 2011, 2014, 2015, 2016, 2017 and 2018 to assess the ongoing stability of the Wilpinjong and Cumbo Creeks during mining. Barnson (2017) developed a

proforma to assist in the assessment of creek stability at each survey location and to enable comparisons to be made between annual survey periods. Annual CSM reports have concluded that overall riparian health is poor, with erosion and bank stability issues present, typical of historically cleared agricultural catchments. Consistent site stability ratings in recent years is associated with prolonged drought conditions, resulting in minimal stream flow and reduced vegetation cover. Data collected by annual CSM to date, indicates that mining activities are not contributing further to channel stability issues in Wilpinjong and Cumbo Creeks.

1.4 Objectives

This report details the findings from the 2019 CSM program and provides a comparison of the regeneration progress of both Wilpinjong and Cumbo Creeks against previous monitoring conducted since 2011.

The CSM program aims to provide qualitative measures of stream bed and bank erosion and channel instability along Wilpinjong and Cumbo Creeks.

The key objectives of the 2019 CSM program are to:

- Evaluate erosional or depositional features of the creek banks
- Record the details of permanent monitoring sites with written descriptions and photographs
- Assess the stability of Wilpinjong and Cumbo Creeks using a rapid assessment methodology
- Compare visual channel stability at each of the permanent monitoring sites against previous monitoring records.

2. Methodology

2.1 Field survey – stability and comparative assessment

The field survey was conducted by ELA ecologists Tom Kelly and Elise Keane between 19 and 22 November 2019.

A total of 59 (49 on Wilpinjong Creek and 10 on Cumbo Creek) permanent monitoring locations were surveyed (Figure 1). Consistent with previous monitoring, surveys involved surveying the designated reach of each site (approximately 100 m) and completing the Bank Erosion Hazard Index (BEHI) assessment. BEHI assessment involves scoring a site on eight quantitative categories outlined below and in **Appendix A**.

The eight BEHI indicators of channel stability that were used to evaluate erosion at each site include:

- Bank Height (m)
- Bank Angle (°)
- Percentage of Bank Height with a Bank Angle Greater than 80°
- Evidence of Mass Wasting (% of Bank)
- Unconsolidated Material (% of Bank)
- Streambank Protection (% of Streambank covered by plant roots, vegetation, logs, branches, rocks, etc.)
- Established Beneficial Riparian Woody – Vegetation Cover
- Stream Curvature Descriptor

The channel stability indicators produce an activity rating that classifies each location from 'Highly Unstable', indicating the drainage line is experiencing severe on-going erosion, to 'Highly Stable', indicating the drainage line is highly stable in function and form. This rating system enables any deterioration or improvement in bank stability to be detected over time. The classification system is detailed below in Table 1.

Table 1: BEHI score ranges for each rating class

Rating	BEHI Score
Highly Stable	0-25
Mod Stable	26-35
Stable	36-45
Unstable	46-55
Mod Unstable	56-65
Highly Unstable	66-85

Field notes and photographs were taken to allow qualitative assessment through comparisons between monitoring periods. This process included written site descriptions using the previous monitoring report (ELA 2019) to make comparisons *in situ*, as well as taking upstream and downstream photographs at each of the permanent monitoring sites. Site descriptions are provided in **Section 3** and copies of site photos are provided in **Appendix B**. Comparison of the 2019 monitoring site (2011 – 2018) photographs has been made by referring to previous reports prepared by Barnson (2017) and ELA (2018 and 2019).

Previously established erosion points along the Wilpinjong Creek were also assessed (Figure 2). These are in areas with moderate to severe erosion and are monitored to determine the presence and extent of on-going erosion.

Management issues and threatened species are recorded opportunistically throughout the surveys, to highlight areas where management intervention is needed.

2.2 Rainfall and flood analysis

Previous WCPL CSM reports have included an analysis of rainfall Intensity-Frequency-Duration (IFD) and exceedance likelihood, with its effect on erosion (Barnson 2017). Rainfall data is included in **Appendix C** and shows that 2019 recorded only 41% of the long-term average rainfall. Consistent with 2017 and 2018 monitoring, it was determined that due to this below average annual rainfall and extremely low flow (**Figure 3** and **Figure 4**) resulting in the absence of significant erosion events at the monitoring sites, IFD and exceedance analysis would not be conducted for the purposes of this report.

Figure 1: Monitoring locations

Figure 2: Active erosion points assessed in 2019

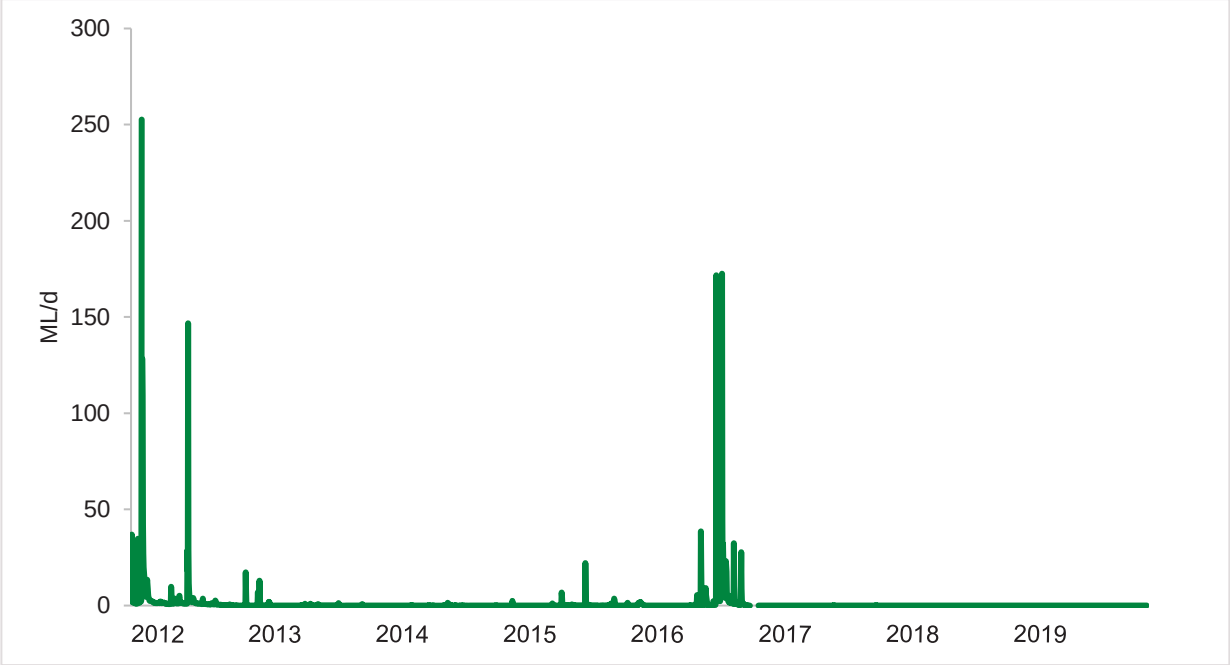

Figure 3: Stream flow upstream of the WCPL mine discharge point EPL 24

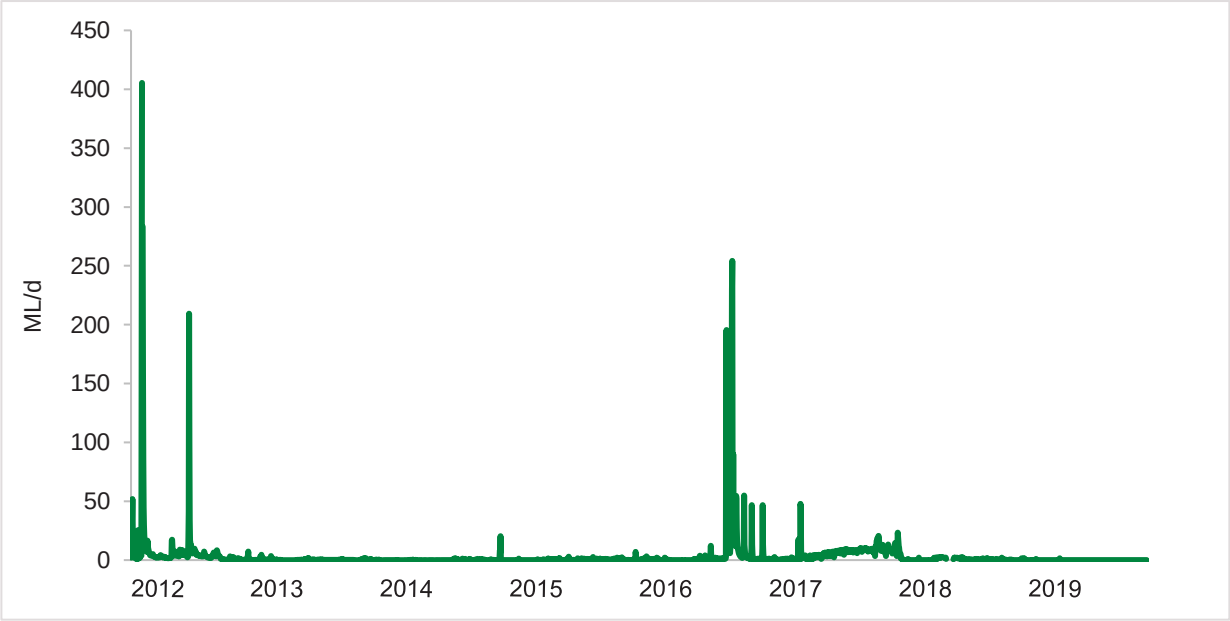

Figure 4: Stream flow downstream of the WCPL mine discharge point EPL 24

3. Results

The results of the CSM are presented below in Table 2 and Table 3. Site descriptions and comparison notes can be found in Table 4.

Table 2: BEHI for Wilpinjong Creek

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	BEHI Indicator								Total	Rating
				1	2	3	4	5	6	7	8		
WCk1	L	4	10	5	2	5	0	2.5	7.5	7.5	5	34.5	Mod Stable
WCk2	R	3.5	9	5	2	5	2.5	2.5	2.5	10	0	29.5	Mod Stable
WCk3	L	3	12	5	2	2.5	5	7.5	10	12.5	5	49.5	Unstable
WCk4	L	3.5	7	5	4	7.5	7.5	7.5	12.5	12.5	0	56.5	Mod Unstable
WCk5	L	3	7	5	2	2.5	2.5	5	7.5	7.5	0	32	Mod Stable
WCk6	L	3	6	2.5	2	2.5	2.5	2.5	2.5	7.5	2.5	24.5	Highly Stable
WCk7	L	2.5	6	2.5	2	2.5	2.5	2.5	2.5	7.5	0	22	Highly Stable
WCk8	L	5	12	7.5	2	0	2.5	7.5	10	15	2.5	47	Unstable
WCk9	R	2	9	2.5	2	7.5	5	5	7.5	15	2.5	47	Unstable
WCk10	R	1.5	15	2.5	0	0	0	7.5	10	15	2.5	37.5	Stable
WCk11	R	1.5	18	0	0	0	0	5	10	10	2.5	27.5	Mod Stable
WCk12	R	2	12	2.5	2	0	0	5	7.5	12.5	5	34.5	Mod Stable
WCk13	L	4	8	5	4	0	2.5	5	7.5	10	5	39	Stable
WCk14	L	1.8	7	2.5	2	0	0	2.5	2.5	12.5	0	22	Highly Stable
WCk15	L	1.8	6	2.5	2	2.5	2.5	2.5	10	10	2.5	34.5	Mod Stable
WCk16	L	2	7	2.5	2	5	2.5	7.5	10	7.5	0	37	Stable
WCk17	R	1.8	4	2.5	2	0	0	2.5	2.5	15	2.5	27	Mod Stable
WCk18	R	2.5	5	2.5	2	5	2.5	5	7.5	15	2.5	42	Stable
WCk19	L	2	4	2.5	2	5	5	5	7.5	15	0	42	Stable
WCk20	L	1.8	5	2.5	2	2.5	2.5	5	7.5	12.5	0	34.5	Mod Stable
WCk21	R	1.3	5	0	2	2.5	2.5	2.5	2.5	15	2.5	29.5	Mod Stable
WCk22	R	1.6	8	2.5	2	0	2.5	5	10	12.5	2.5	37	Stable
WCk23	R	2.5	12	2.5	2	0	0	7.5	12.5	15	5	44.5	Stable
WCk24	R	1.7	10	2.5	0	2.5	5	10	12.5	15	2.5	50	Unstable
WCk25	L	1.7	7	2.5	2	2.5	7.5	5	10	15	2.5	47	Unstable
WCk26	L	3.5	10	5	2	7.5	5	7.5	10	15	2.5	54.5	Unstable

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	BEHI Indicator								Total	Rating
				1	2	3	4	5	6	7	8		
WCk27	R	2.8	5	2.5	6	7.5	5	7.5	10	15	2.5	56	Mod Unstable
WCk28	L	2.5	5	2.5	2	5	5	5	7.5	12.5	2.5	42	Stable
WCk29	L	3.6	8	5	2	5	5	5	7.5	15	2.5	47	Unstable
WCk30	R	2.8	12	2.5	2	0	2.5	2.5	2.5	12.5	2.5	27	Mod Stable
WCk31	R	3	6	2.5	4	5	5	7.5	10	15	2.5	51.5	Unstable
WCk32	R	3.2	7	5	4	7.5	5	7.5	10	15	2.5	56.5	Mod Unstable
WCk33	L	3.2	6	5	4	7.5	5	7.5	10	10	5	54	Unstable
WCk34	R	2.4	6	2.5	4	5	5	7.5	7.5	15	5	51.5	Unstable
WCk35	R	2.2	13	2.5	2	0	2.5	5	7.5	15	2.5	37	Stable
WCk36	R	2	15	2.5	2	0	2.5	2.5	2.5	15	2.5	29.5	Mod Stable
WCk37	R	2	10	2.5	2	2.5	2.5	7.5	10	15	2.5	44.5	Stable
WCk38	L	3.1	6	5	2	2.5	2.5	5	7.5	10	5	39.5	Stable
WCk39	L	3.2	7	5	4	2.5	5	10	10	15	2.5	54	Unstable
WCk40	R	3.2	14	5	2	0	5	10	12.5	15	0	49.5	Unstable
WCk41	R	2.8	8	2.5	2	2.5	2.5	2.5	7.5	15	0	34.5	Mod Stable
WCk42	R	3.8	6	5	4	5	7.5	10	10	12.5	2.5	56.5	Mod Unstable
WCk43	L	3.1	5	5	4	7.5	2.5	7.5	10	15	2.5	54	Unstable
WCk44	R	1.7	3	2.5	2	2.5	2.5	5	2.5	15	2.5	34.5	Mod Stable
WCk45	L	3.2	7	5	2	2.5	5	5	7.5	7.5	5	39.5	Stable
WCk46	R	2.2	5	2.5	4	5	2.5	5	7.5	10	2.5	39	Stable
WCk47	R	2.2	6	2.5	2	2.5	5	5	7.5	12.5	0	37	Stable
WCk48	L	2.7	8	2.5	2	2.5	5	5	7.5	12.5	2.5	39.5	Stable
WCk49	L	3.8	10	5	4	2.5	2.5	7.5	10	12.5	2.5	46.5	Unstable

Table 3: BEHI for Cumbo Creek

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	BEHI Indicator								Total	Rating
				1	2	3	4	5	6	7	8		
CCk1	R	1.8	10	2.5	0	0	0	2.5	2.5	15	0	22.5	Highly Stable
CCk2	R	1.3	8	0	2	2.5	5	5	7.5	15	5	42	Stable

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	BEHI Indicator								Total	Rating
				1	2	3	4	5	6	7	8		
CCk3	L	0.4	2	0	0	0	0	0	0	15	2.5	17.5	Highly Stable
CCk4	R	1	13	0	0	0	0	0	2.5	15	2.5	20	Highly Stable
CCk5	R	1	8	0	0	0	0	5	2.5	15	2.5	25	Highly Stable
CCk6	R	1.8	10	2.5	2	0	2.5	2.5	2.5	15	2.5	29.5	Mod Stable
CCk7	R	0.5	2	0	2	2.5	0	0	0	15	2.5	22	Highly Stable
CCk8	L	2	15	2.5	0	0	0	0	0	15	2.5	20	Highly Stable
CCk9	L	0.7	2	0	2	2.5	2.5	0	0	15	2.5	24.5	Highly Stable
CCk10	L	0.7	4	0	2	2.5	2.5	0	0	15	2.5	24.5	Highly Stable

Table 4: Monitoring site descriptions - Wilpinjong Creek and Cumbo Creek

Site	Upstream	Downstream
WCk1	• Decreased cover in channel bed compared to 2018 • Limited vegetation cover on banks and stream bed • Localised erosion along stock tracks • Sandstone bedrock exposed	• Decrease in vegetation cover, with evidence of grazing by stock, including cattle hoof prints • Patches of bare soil • Good leaf litter in channel and on banks • Bedrock exposed in creek bed
WCk2	• Dieback of *Phragmites australis* (Common Reed), decreased vegetation cover compared to 2018 • Decrease in groundcover on banks, however, banks remain stable • Localised erosion along stock tracks	• Dieback in groundcover • High leaf litter cover
WCk3	• Decrease in vegetation cover, with little groundcover on banks and in stream bed • Evidence of cattle in channel, with scats and tracks present • Localised erosion along stock tracks	• Decrease in groundcover, with very minimal cover present • Left bank bare and showing signs of erosion, not currently active • Some Large Woody Debris (LWD) on right bank
WCk4	• Decrease in vegetation cover in channel bed • Right bank stable except for stock tracks • Left bank unstable, significant bank collapse and undercutting, not currently active	• Erosion on left bank not currently active • Right bank is stable downstream of the fence • *Phragmites australis* has dried up and mostly dead • Stock impacting on stability of creek • Animal crossing through channel
WCk5	• Eucalypt regeneration in channel bed • *Phragmites australis* dried up and mostly dead • Wombat holes on right bank • Gully cutting on left bank, not active in the past year, however, is still potentially unstable	• Decrease in ground cover on right bank • *Phragmites australis* has dried up in channel • Left bank has reasonable cover of grass/herbs/shrubs
WCk6	• Fallen trees in channel bed • Eucalypt regeneration in channel • Stock tracks on both banks • *Gahnia aspera* (Rough Saw-sedge) and shrubs growing on left bank • Good litter cover in creek bed	• Wombat hole on right bank • *Phragmites australis* dried up and mostly dead • Good canopy regeneration • Good cover of leaf litter
WCk7	• Decreased stream cover of *Phragmites australis* • Wombat burrows on right bank	• Good LWD cover on right bank • Good vegetation growth on both banks

Site	Upstream	Downstream
		• Good leaf litter cover in channel
WCk8	• Vegetation cover in channel decreased, with *Phragmites australis* died off • Little groundcover on banks • Wombat holes on both banks	• Right bank stable • Animal tracks, wombat holes on left bank and bare patches on steep bank • Some *Phragmites australis* in channel with very low cover
WCk9	• Decrease in vegetation cover in channel, with *Phragmites australis* died off • Right bank steep and bare in some place • Wombat burrows on right bank	• Steep eroded banks on right bank • *Phragmites australis* in channel, with some dieback • Rabbit and wombat holes on left bank
WCk10	• Decrease in groundcover on banks • Wombat holes on left bank	• Channel bare, with some macrophyte cover further downstream • Bare soil on steep sections of right bank • Left bank is stable • Decrease in vegetation cover on banks
WCk11	• Wombat activity on bench on right bank leaving bare patches • Macrophyte dieback	• Decrease in macrophytes and ground cover • Animal tracks on left bank • Wombat holes on right bank bench • Good leaf litter in channels and on banks
WCk12	• Vegetation cover decreased on right bank • Some minor *Casuarina cunninghamiana* (River Sheoak) regrowth on left bank • Increased wombat activity in channel and on right bank • *Rubus fruticosus* (Blackberry) noted in 2018 has died off	• Decrease in vegetation on right bank • LWD, litter and wombat burrows on right hand bank bench • Increased wombat activity in channel
WCk13	• Increase wombat activity on right bank, and wombat burrows on left bank • Some bare exposed areas on both left and right bank in steep sections • Channel bare, with dieback of *Phragmites australis* and sand/gravel accumulation	• Undercutting on left bank downstream of reach not currently active • Left bank steep and bare • *Phragmites australis* has dried off and is mostly dead on left bank • Sand and gravel in channel bed • Wombat burrows on left bank
WCk14	• Wombat burrows in both right and left bank • Pig digging in channel • Very little vegetation cover in channel bed • Some debris in channel	• Decrease in groundcover • Some dieback of vegetation on left bank • Wombat burrows on both banks • Very little vegetation cover in channel bed
WCk15	• Wombat burrows in both banks • Good vegetation cover on right bank, moderate on left bank	• Majority of vegetation on the right bank has died off • LWD on left bank

Site	Upstream	Downstream
	• Some older erosion on left bank, not currently active • Some leaf litter accumulation in channel	• Reduction in *Phragmites australis* in channel bed
WCk16	• Sand/gravel accumulation in channel • Wombat holes in channel bed and right bank • Reduced vegetation cover on right bank • Left bank steep and bare	• Sand/gravel deposits in channel • Most of *Phragmites australis* has died back • Left bank very little vegetation cover • LWD on right bank and in channel bed
WCk17	• Well vegetated banks and channel bed with *Phragmites australis* • Sand/gravel accumulations in channel with some iron staining • Animal tracks present • Wombat burrows in both banks	• Good cover of *Phragmites australis* on bank • Animal tracks crossing the creek • Sand/gravel substrate in channel
WCk18	• Wombat burrows in both banks • Decrease in groundcover, with some bare patches • Animal tracks across channel beds • Sand/gravel accumulation in channel	• Wombat burrows in both banks • Erosion on right bank currently not active • Good vegetation cover in channel bed, with *Phragmites australis* • Sand and gravel substrate in channel
WCk19	• Good vegetation cover of grasses/rushes in channel and banks • Some animal tracks on left bank • Wombat holes on right bank • Old erosion top of right bank, currently not active	• Good vegetation cover in channel and on right bank • Mass wasting on top of left bank similar to 2018
WCk20	• Bank and channel well vegetated • Some lateral erosion on left bank, not currently active • Animal tracks through channel • Wombat burrows upper right bank, leading to bare patches	• Channel and banks well-vegetated with *Phragmites australis* and *Lomandra* spp. • Minor lateral erosion on both banks, not currently active • Some regeneration on left bank
WCk21	• Good vegetation cover on right bank • Some *Phragmites australis* dieback in channel • Some bare exposed areas on left bank, mainly due to animal tracks • Debris and leaf litter build up in channel	• Good vegetation growth in channel and right bank • Erosion on left bank not currently active
WCk22	• Good vegetation cover in channel and on left bank • Reduced groundcover on right bank • Wombat burrows in left bank • Old erosion on right bank, currently not active	• Erosion evident on right bank, not currently active • Right bank bare, with no groundcover • Good vegetation cover in channel and left bank • No riparian tree cover

Site	Upstream	Downstream
WCk23	• Good vegetation cover in channel • Left bank moderate vegetation cover with some bare patches • Right bank low groundcover, with animal tracks creating bare patches • Erosion at top of both banks, leading to exposed patches	• Good vegetation cover in channel • Bare soil on both banks, particularly the right bank • Canopy species regeneration on both banks
WCk24	• Good cover of *Lomandra* spp. on left bank • Bare exposed patches with animal tracks on right bank • Good vegetation cover in channel bed • Wombat and rabbit burrows present on left bank	• Good vegetation cover in channel • Good vegetation cover on left bank with the exception of animal tracks • Bare soil patches and erosion on right bank, downstream of discharge point
WCk25	• Old erosion on right bank, not currently active • Bank vegetation dominated by thistles • No riparian zone • Reduced groundcover • Regeneration on right bank	• Significant bare soil patches with notching erosion occurring • Reduced groundcover on banks and reduced macrophytes in channel • LWD on right bank
WCk26	• Exposed areas on top of left bank • Right bank remains stable • Some wombat and rabbit burrows in top of left bank • Blackberry has died	• Erosion not currently active • Wombat burrows on top of left bank
WCk27	• In channel vegetation remains similar to 2018 • Erosion on right bank is currently not active, however remains unstable, leading to steep and bare bank	• Erosion on right bank not currently active • Left bank bare
WCk28	• Decrease in vegetation cover in channel and on right bank • Bare sections present on left bank • Regeneration at top of left bank	• Decreased vegetation cover in channel • Sections of left bank steep and eroded • Decreased cover on right bank, with some bare patches
WCk29	• Decrease in vegetation cover in channel due to macrophyte dieback • Left bank not as steep and good cover of grass compared to downstream	• Decrease in vegetation cover in channel due to macrophyte dieback • Wombat burrows present right bank • Top half of left bank very steep, erosion not currently active • Good vegetation cover on bottom half of left bank, with some animal tracks • Blackberry in channel
WCk30	• *Phragmites australis* die off in channel • Some bare areas on left bank • Blackberry noted in 2018 has died	• No change to gully forming on right bank on downstream end of reach • No change to left bank eroded section with exposed bare soil

Site	Upstream	Downstream
	• Wombat burrows in both banks • Good general regeneration on both banks	
WCk31	• Dieback of macrophytes in channel • Erosion on right bank not currently active, large areas of bare soil still present • No salt crystallisation evident	• Dieback of macrophytes within channel • Right bank soil exposure from animal tracks and steep slope • Some minor gullying evident on right bank • Good vegetation cover on left bank, with some erosion mid bank
WCk32	• Macrophyte dieback and flattened • Left bank showing signs of erosion, with bare patches on the mid to upper bank • Right bank very steep erosion leading to exposed tree roots • Left bank good vegetation cover	• Right bank is steep and eroded, currently stable • Blackberry in right bank gully dead • Dieback of macrophytes in channel
WCk33	• Some macrophyte dieback, however, generally good cover of grasses in channel and on right bank • Areas of erosion on left bank not currently active, however bank is steep and bare • Tree cover present on left bank with some regeneration but little ground cover	• Dieback in vegetation cover in channel • Left bank steep, bare and eroded with exposed tree roots, erosion not currently active • Tree cover moderate, but no groundcover on left bank • LWD on left bank
WCk34	• In channel vegetation cover remains high, with some *Phragmites australis* dried out • Right bank stable but some wombat burros and animal tracks • Erosion on face of left bank and right bank not currently active	• Right bank erosion not currently active • Good vegetation cover on left bank • Blackberry at top of right bank dead • Some decrease in vegetation cover
WCk35	• In stream vegetation cover remains high • Lower section of left bank remains stable, however there has been a decrease in ground cover • Right bank erosion and bare soil predominant, as well as animal tracks evident	• Decrease in vegetation cover on right bank • Regeneration downstream of reach on left bank • Good vegetation cover in channel
WCk36	• Dieback of *Phragmites australis* in channel • Bare soil from stock tracks and erosion • Left bank remains steeply slowed and concave • Top of left bank still steep, showing signs of erosion, however not currently active	• Slumping on right bank not currently active • Some undercutting and exposed bare soil at downstream end of left bank • Decrease in vegetation cover in channel

Site	Upstream	Downstream
WCk37	• Left bank remains well vegetated (grazed) with some lateral erosion • Some wombat burrows in left bank • Right bank bare, with very little vegetation cover • Stock tracks causing bare areas and erosion on right bank	• Wombat burrows on left hand bank • Right bank groundcover similar to 2018, with bare soil • Stock tracks evident on right bank • LWD on left bank • Moderate vegetation cover on left bank, with some lateral erosion
WCk38	• Decrease in vegetation in channel, channel bare with some leaf litter accumulation • Stock tracks causing localised erosion on both banks • Decrease in vegetation cover on right bank, actively grazed • Left bank erosion currently not active, bank is steep and bare	• Moderate vegetation cover on right bank • Low vegetation cover on left bank and channel
WCk39	• Decrease in groundcover on both banks • Left bank erosion not currently active, bank bare • Wombat burrows on both banks • Decrease in channel vegetation cover, continues to be grazed by cattle	• Decrease in vegetation on right bank • Erosion on left bank not currently active, upper left bank steep and bare • Wombat burrows on right bank
WCk40	• Decrease in vegetation cover in channel, vegetation grazed and evidence of stock hoof prints • Left bank well vegetated, with some lateral erosion, though not currently active • Bare patches of exposed bank still present on right bank, consistent with previous years	• Slight decrease in vegetation in channel bed, stable but actively grazed • Right bank has bare slope and exposed bedrock
WCk41	• Dieback of in channel vegetation cover, and continues to be grazed by cattle • Left bank has good vegetation cover • Right bank has exposed soil, bedrock and erosion, not currently active • Stock tracks in left and right bank	• Creek bed and left bank well vegetated and stable • Some stock tracks in channel bed • Well established wombat holes on left bank • Right bank erosion not currently active
WCk42	• Decreased vegetation cover in channel, with thistles in channel • Stock on left bank and in channel • Right bank erosion currently not active, bedrock exposed and sand and gravel sediment deposits • Gully developing on right bank upstream of large tree, with roots of tree exposed • Rehabilitation activities required on right bank, along with stock removal	• Decrease in groundcover • Stock in channel • Wombat burrows on left bank • Erosion of right bank not currently active, tree roots exposed

Site	Upstream	Downstream
WCk43	• Decrease in vegetation cover in channel bed • Erosion on left bank not currently active, however erosion and stock tracks leading to unstable sections • Vegetation cover on right bank dieback	• Blackberry remains dead • LWD in channel • Decrease in vegetation cover, actively grazed • Left bank minimal ground cover, slope steep and eroding with exposed tree roots
WCk44	• Decrease in overall vegetation cover • Bare sections on both banks due to stock tracks • Channel bed bare and stock prints evident • Wombat burrows in left bank • Left bank lateral erosion, not currently active	• Decrease in vegetation cover in channel bed • Both banks lateral erosion and patchy bare soil • Stock tracks on left bank
WCk45	• In stream vegetation dieback • Low groundcover on left bank • Both banks stable	• Vegetation cover very low on left bank • Decrease in groundcover in channel • Minor localised erosion caused by stock access on left bank
WCk46	• Channel actively grazed, with exotic groundcover present • Good leaf litter in channel and on both banks • Decrease in vegetation on both banks	• Good and stable vegetation but actively grazed • Left bank remains stable with no active erosion, right bank has minor exposed steep sections vulnerable to erosion • Animal tracks down left bank
WCk47	• All in stream macrophytes are dry, majority are dead and flattened • Banks are steep but stable	• Dieback of macrophytes in channel • Decrease in groundcover on right bank • Stock causing localised erosion
WCk48	• Decrease in vegetation on right bank bar • Left bank steep, but stable apart from around animal tracks and wombat holes • Right bank stabilised by rock cover	• Decrease in ground cover on right bank • Animal tracks along channel and right bank
WCk49	• Good cover of grasses on channel • Decrease in vegetation on right bank, with very low cover • Left bank showing signs of stock tracks and localised erosion • Vegetation has been heavily grazed	• Decrease in vegetation cover in channel and right bank • Left bank steep but currently stable • Localised erosion caused by stock access • Wombat holes on right bank
CCk1	• Site remains well vegetated and stable • Dieback of macrophyte vegetation in channel • No tree cover	• Decrease groundcover on right bank

Site	Upstream	Downstream
CCk2	• Good vegetation cover in channel and on left bank • Evidence of erosion on mid and upper sections of right bank • Some debris in channel	• Good vegetation cover and stable in channel and left bank • Some bare soil and bed rock exposure on right bank
CCk3	• Dieback of macrophyte vegetation in channel • Decrease in ground cover on banks	• Dieback of macrophyte vegetation in channel • Groundcover on banks has slightly died off since 2018 but remains stable
CCk4	• Good groundcover in channel and on both banks • Animal tracks on right bank	• Site remains stable • Good and stable vegetation cover
CCk5	• Channel remains well vegetated • Decrease in groundcover on right bank, with some bare ground on upper right bank	• Decrease in groundcover on right bank, with some bare ground on upper right bank
CCk6	• Area well vegetated • Leaf litter build up on top of right bank • Some Eucalypt regrowth on right bank	• Some vegetation has died back, but overall remains well vegetated and stable
CCk7	• Decrease in groundcover, with majority dried out • Some bare bank low of left bank • Banks remain stable	• Some dieback of groundcover, but overall remains well vegetated and stable • Minor erosion on left bank not currently active
CCk8	• Vegetation cover in channel and both banks dried out • Saffron Thistles on left bank • Very limited riparian zone apart from groundcover	• Decrease in ground cover on banks and in channel
CCk9	• Decrease in vegetation, dieback • Saffron Thistle prevalent on both banks	• Minor lateral erosion, not currently active, with exposed soil on both banks • Decrease in vegetation cover, dieback • Animal track across creek
CCk10	• Decrease in vegetation cover • Very limited riparian zone apart from groundcover	• Decrease in vegetation cover • Lateral erosion on left bank

Three species, *Opuntia* sp. (Prickly Pear), Blackberry and *Rosa rubiginosa* (Sweet Briar), which are classified as regional priority weeds under the Central Tablelands Regional Strategic Weed Management Plan 2017 – 2022 (Central Tablelands Local Land Services 2017), were identified along Wilpinjong Creek. These management issues are mapped below, in Figure 5**.**

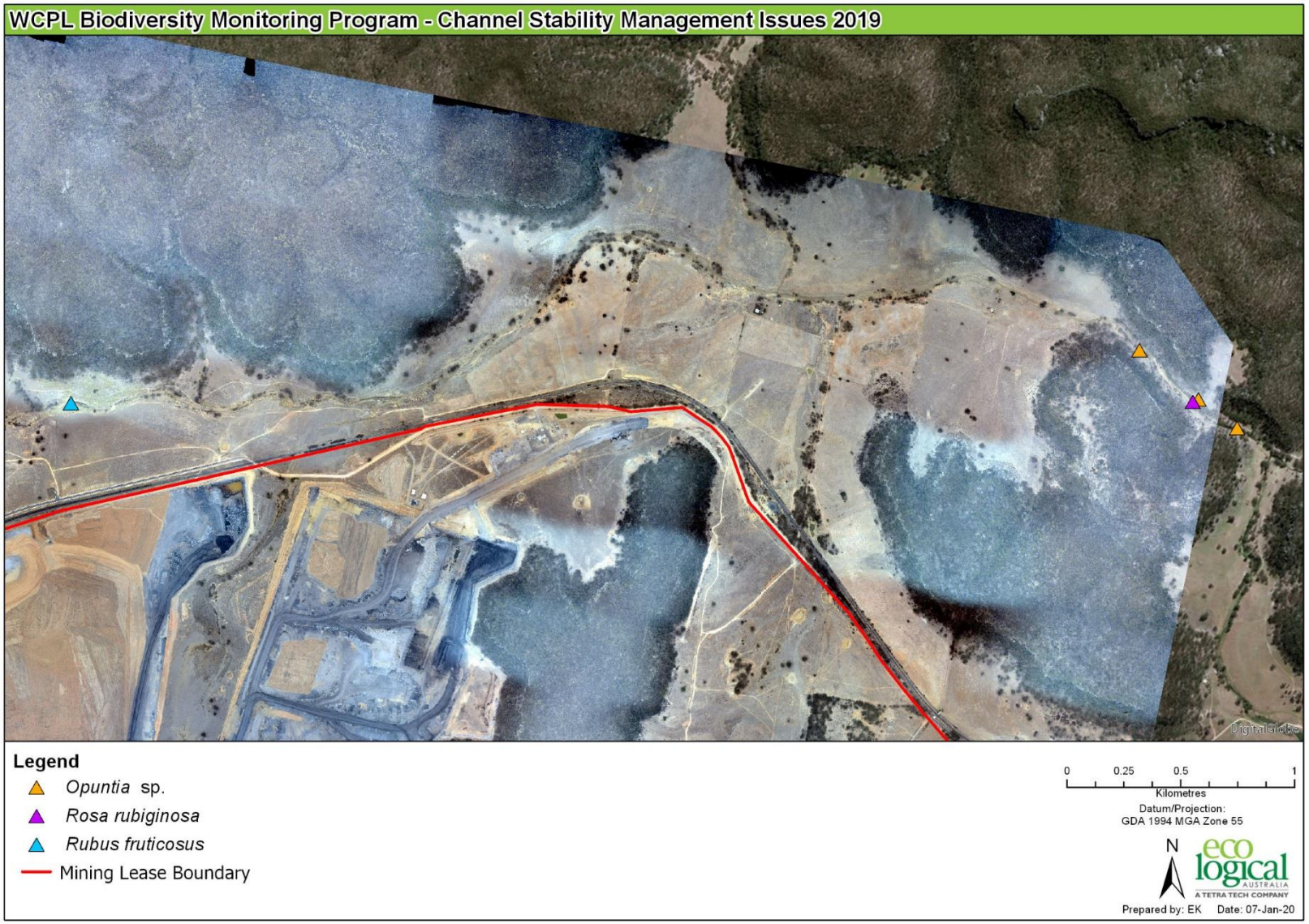

Figure 5: Management Issues 2019

4. Discussion and Recommendations

Of the 49 sites surveyed along Wilpinjong Creek, three were classified as Highly Stable, 13 Moderately Stable, 15 Stable, 14 Unstable and four Moderately Unstable (Table 2). As such, a total of 31 sites recorded scores in the stable range, whilst 18 sites recorded scores in the unstable range. The lowest scoring sites (all Moderately Unstable) were WCk4, WCk27, WCk32 and WCk42, and were typified by mass sediment wasting and a low percentage of streambank protection and riparian woodland vegetation cover. Both site WCk4 (E1 and E3) and WCk32 (E8) are also located on the same reach as designated Erosion points, indicating the mass sediments wasting that has occurred at these sites.

The western section of Wilpinjong Creek (incorporating sites WCk1 to WCk8) contains good areas of natural regeneration, with overall moderate to good riparian woodland vegetation and habitat present. Within 2019, there was a decrease in stream vegetation cover at most sites, particularly due to dieback of *Phragmites australis* and other ground cover species.

The middle section of Wilpinjong Creek (incorporating sites WCk18 to WCk44) is characterised by cleared adjacent paddocks and narrow, scattered riparian woodland (where present). Widespread historic clearing in this section of the creek has a pronounced influence on the channel stability scores with unstable BEHI scores recorded for *Streambank Protection* and *Established Beneficial Riparian Woody Vegetation Cover*.

The eastern section of Wilpinjong Creek (incorporating sites WCk45 to WCk49) is characterised by a relatively steep and narrow valley, which has resulted in a straight channel with high bank height.

Of the ten sites surveyed along Cumbo Creek, eight were Highly Stable, one Moderately Stable and one Stable (Table 3). The reach of Cumbo Creek surveyed is characterised by a shallow, meandering channel with low stable banks. The adjacent paddocks have been historically cleared with only very sparse riparian woodland vegetation remaining. Despite the lack of woody riparian vegetation, the creek remains in a stable condition as evidenced by all sites recording BEHI scores in the stable range.

4.1 Multi-year comparisons

Following on from the baseline channel stability assessment of Wilpinjong and Cumbo Creeks undertaken in 2005 as part of the WCPL EIS (WCPL 2005), annual monitoring has been undertaken during 2011, 2014, 2015, 2016, 2017 and 2018. The EIS concluded that both Wilpinjong and Cumbo Creeks were affected by pre-mining agricultural land management practices, resulting in erosion and creek bank instability. Annual monitoring since 2011 shows that the channel stability has remained relatively constant, both upstream and downstream of WCM. This indicates that mining activities are not contributing further to channel instability, with any changes likely resulting from seasonal variations in rainfall and vegetation cover, along with the influence of continued stock access at selected sites on Wilpinjong Creek.

4.1.1 Site stability scores

Site channel stability data in the form of BEHI scores are available from 2016 – 2018 for direct comparison. Site stability ratings (based on BEHI scores) for Wilpinjong Creek sites are presented in Table 5, with Cumbo Creek ratings presented in Table 6. Differences in ratings were only noted as

'Improved' or 'Declined' where a trend was observed over two consecutive years. If no differences were observed over three consecutive years (inclusive of 2019), the ratings were determined to be unchanged, indicating a consistent stability rating for that site. For Wilpinjong Creek, ratings improved at one site, remained unchanged at 43 sites and declined at five sites. For Cumbo Creek, ratings improved at one site, remained unchanged at eight sites and declined at one site.

These largely consistent results from 2016 to 2019, reflect the overall stable nature of both creeks in what has been a prolonged dry period with below average rainfall resulting in a lack of downstream and lateral flow. Declines observed in stability ratings between 2018 and 2019 monitoring can be mostly attributed to decreased vegetation cover, with die off of macrophyte and groundcover observed during 2019 monitoring, at sites both upstream and downstream of the WCM. Decreased vegetation cover is directly linked to decreased scores for *Streambank Protection* and associated decreased scores for *Unconsolidated Material*. Macrophytes such as *Phragmites australis*, have a dependency on water availability, with prolonged dry conditions at these sites, resulting in widespread dieback of the species (NCCMA, 2015).

There is potential that some variation in ratings can be attributed to observed variation between years, given the subjective nature of some of the BEHI indicators. In particular, variation in ratings is noted between 2016 (Barnson) and 2017 (ELA). To account for this variability, multi-year comparisons have been completed mostly based on ratings, to highlight overall trends, rather than minor variations in individual BEHI indicator scores.

Table 5: Wilpinjong Creek site stability scores 2016 - 2019 comparison

Site	2016 Rating	2017 Rating	2018 Rating	2019 Rating	Difference
WCk1	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk2	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk3	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk4	Highly Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Unchanged
WCk5	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk6	Stable	Moderately Stable	Highly Stable	Highly Stable	Improved
WCk7	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
WCk8	Stable	Stable	Stable	Unstable	Unchanged
WCk9	Unstable	Stable	Stable	Unstable	Unchanged
WCk10	Highly Stable	Highly Stable	Moderately Stable	Stable	Declined
WCk11	Moderately Stable	Highly Stable	Highly Stable	Moderately Stable	Unchanged
WCk12	Moderately Stable	Highly Stable	Highly Stable	Moderately Stable	Unchanged
WCk13	Stable	Moderately Stable	Stable	Stable	Declined
WCk14	Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
WCk15	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk16	Highly Stable	Moderately Stable	Moderately Stable	Stable	Unchanged
WCk17	Moderately Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged

Site	2016 Rating	2017 Rating	2018 Rating	2019 Rating	Difference
WCk18	Stable	Stable	Stable	Stable	Unchanged
WCk19	Unstable	Stable	Stable	Stable	Unchanged
WCk20	Unstable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk21	Unstable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk22	Moderately Unstable	Stable	Stable	Stable	Unchanged
WCk23	Moderately Unstable	Stable	Stable	Stable	Unchanged
WCk24	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk25	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk26	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk27	Stable	Unstable	Moderately Unstable	Moderately Unstable	Declined
WCk28	Unstable	Stable	Stable	Stable	Unchanged
WCk29	Unstable	Stable	Stable	Unstable	Unchanged
WCk30	Stable	Moderately Stable	Highly Stable	Moderately Stable	Unchanged
WCk31	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk32	Moderately Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Unchanged
WCk33	Moderately Unstable	Unstable	Unstable	Unstable	Unchanged
WCk34	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk35	Stable	Moderately Stable	Stable	Stable	Declined
WCk36	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk37	Stable	Stable	Stable	Stable	Unchanged
WCk38	Stable	Stable	Stable	Stable	Unchanged
WCk39	Stable	Unstable	Unstable	Unstable	Unchanged
WCk40	Unstable	Unstable	Unstable	Unstable	Unchanged
WCk41	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk42	Highly Unstable	Moderately Unstable	Moderately Unstable	Moderately Unstable	Unchanged
WCk43	Not surveyed	Unstable	Unstable	Unstable	Unchanged
WCk44	Stable	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk45	Stable	Stable	Stable	Stable	Unchanged
WCk46	Stable	Moderately Stable	Moderately Stable	Stable	Unchanged
WCk47	Stable	Moderately Stable	Stable	Stable	Declined
WCk48	Stable	Stable	Stable	Stable	Unchanged
WCk49	Stable	Stable	Stable	Unstable	Unchanged

Table 6: Cumbo Creek site stability score 2016 - 2019 comparison

Site	2016 Rating	2017 Rating	2018 Rating	2019 Rating	Difference
CCK1	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK2	Moderately Stable	Stable	Stable	Stable	Unchanged
CCK3	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK4	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK5	Moderately Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK6	Moderately Stable	Highly Stable	Moderately Stable	Moderately Stable	Declined
CCK7	Not surveyed	Moderately Stable	Highly Stable	Highly Stable	Improved
CCK8	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK9	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK10	Highly Stable	Highly Stable	Highly Stable	Highly Stable	Unchanged

4.1.2 Photographic comparisons

Photographic comparisons between sites during 2017, 2018 and 2019 monitoring are included in **Appendix B**. Photos taken from 2011, 2014, 2015 and 2016 monitoring were also compared, however, digital copies were not available to be included in this report.

Comparisons indicate that there has been little observable change in the morphology of the stream channel and banks at each monitoring site, with no new significant erosional features evident. Some notable differences were apparent relating to vegetation cover, mostly through reduction in macrophyte cover. This is clearly evident in the reduction of 'green' vegetation visible in the photos from 2017 to 2019 for the majority of sites. Water levels were also noticeably lower in 2019 compared to previous years at both Wilpinjong and Cumbo creeks, with several sites dry for the first time since 2011. Reductions in vegetation cover and water levels visible in site photos were observed both upstream and downstream of the WCPL water discharge location and point to the influence of prolonged drought conditions experienced since 2017 (see **Appendix C**).

4.2 Erosion points

Table 7 provides photos of the significant erosion points along Wilpinjong and Cumbo creeks (see Figure 2). These sites were identified as having moderate to severe erosion historical erosion and the potential for continued erosion during times of downstream and lateral flow. Overall, the erosion points appear largely consistent with previous years, with no evidence of recent downstream erosion. Given the large areas of bare soil and multiple erosional gullies present at these sites, it is likely that lateral erosion would still be occurring during high rainfall events, because of increased runoff velocities from the surrounding cleared landscape. However, no such rainfall events occurred in 2019, with no instances of significant lateral erosion evident through both site inspections and photo comparisons.

Revegetation of the creek bank adjacent to E6, E7, E8 and E9 utilising native riparian woodland species was completed in 2019 (**Section 4.3**). E8 has been rehabilitated with fill placed and sloped to repair the

ramp and allow continued vehicle access across Wilpinjong Creek. A small rill has developed downslope which should continue to be monitored.

Revegetation and remediation methods recommended for these sites are included in Table 7 and discussed further in **Section 4.3**.

Table 7: Significant erosion points and suggested remediation works

Erosion point	Image	Notes / suggested works
E1 (768557, 6422438)		Revegetation and check dams (**Section 4.3**).
E2 (768469, 6422527)		Revegetation and mulching (**Section 4.3**).

Erosion point	Image	Notes / suggested works
E3 (768558, 6422432)		Revegetation and check dams (**Section 4.3**).
E4 (768614, 6422382)		Check dams (**Section 4.3**).
E6 (772166, 6420287)		Revegetation and check dams (**Section 4.3**).

Erosion point	Image	Notes / suggested works
E7 (772431, 6420352)		Revegetation (**Section 4.3**).
E8 (773014, 6420339)		Continue to monitor rill

Erosion point	Image	Notes / suggested works
E9 (773397, 6420376)		Revegetation (**Section 4.3**).
E10 (773772, 6420328)		Revegetation and mulching (**Section 4.3**).

Erosion point	Image	Notes / suggested works
E11 (771670, 6419956)		Revegetation and mulching (**Section 4.3**).

4.3 Revegetation and remediation

Revegetation works were completed in 2019 on a 1.6 km section of Wilpinjong Creek, approximately between sites WCk27 and WCk25 (see Figure 1). Revegetation was undertaken on both sides of the creek using tubestock of local native species listed in Table 8. Plantings occurred in lines parallel to the top of the bank and utilised both rip lines and individual holes, placed approximately 5 m apart.

Further revegetation works along both Wilpinjong and Cumbo creeks are planned for 2020. These plans detail revegetation of approximately 2.1 km of Wilpinjong Creek and 1.9 km of Cumbo Creek using native species including those listed in Table 8.

Additional revegetation works are also recommended to target erosion points E1 to E3, where the potential for further lateral erosion exists. In these areas, revegetation works should extend to a minimum distance equal to the height of the adjacent eroded bank, to reinforce the existing bank and provide space for the bank to partially erode whilst the vegetation becomes established (Abernathy and Rutherford 1999). The application of mulch to the bank sides (including hydro-mulch) is recommended to assist stabilisation until vegetation establishes, along with the installation of coarse-rock, large-woody debris, coir logs and/or hay bale check dams to reduce water flow in designated erosion points. Fencing works will also assist in excluding native and introduced fauna from revegetation and remediation areas.

Scattered Regional Priority Weeds were present throughout Wilpinjong Creek and included Prickly Pear, Blackberry and Sweet Briar (Figure 5). It was noted during field surveys that Blackberry has died off since 2018 monitoring at sites WCk12, WCk26, WCk30, WCk32, WCk34 and WCk43. Continued targeted spot spraying of these weeds is recommended in association with remediation works.

Table 8: Native species used for Wilpinjong Creek revegetation works

Scientific Name	Common Name
Native trees	
Angophora floribunda	Rough-barked Apple
Casuarina cunninghamiana	River Sheoak
Eucalyptus blakelyi	Blakely's Red Gum
Eucalyptus melliodora	Yellow Box
Native shrubs	
Acacia decora	Western Silver Wattle
Acacia floribunda	Gossamer Wattle
Native ground cover	
Lomandra spp.	Mat-rush

4.4 Exclusion of livestock

Livestock (cattle) access to the riparian zone continues to impact on the overall stability and riparian health of both Wilpinjong and Cumbo creeks. Drought conditions have led to reduced vegetation within the channel and along banks as well as in the surrounding areas, with livestock grazing increasing pressure on this vegetation. Evidence of stock were observed within the eastern section of Wilpinjong Creek (incorporating sites WCk36 to WCk45 and site WCk49), as well as the far-western section (incorporating sites WCk3 to WCk6) during 2019 monitoring. Excluding stock from the riparian zone in these areas is recommended to improve creek stability and health and assist natural regeneration.

5. Conclusion

The channel stability of both Wilpinjong and Cumbo Creeks is characteristic of ephemeral systems in agricultural landscapes, consistent with other creeks in the surrounding region. Both creek systems exhibit characteristic channel stability issues associated with agricultural landscapes including:

- Historically cleared and degraded riparian vegetation and the presence of exotic species, including Regional Priority Weeds such as Prickly Pear, Blackberry and Sweet Briar
- Lateral gully-erosion at several locations, as a result of increase runoff velocity occurring perpendicular to the creek line from adjacent cleared paddocks
- Continued stock access contributing to bank instability, reducing in-stream and riparian vegetation and hampering natural regeneration
- Other introduced and native fauna (e.g. European Rabbit and Common Wombat) burrowing within the riparian zone.

Erosion and bank stability issues within the Wilpinjong and Cumbo Creeks are the result of historic agricultural practices within the riparian zone, including widespread clearing and direct stock access to the bank and channel. The consistency of creek stability ratings both upstream and downstream of the WCM since the commencement of monitoring indicates that mining activities are not contributing further to channel stability issues. Changes to ratings recorded through monitoring can be directly linked to seasonal variations in rainfall and vegetation cover, along with the influence of continued stock access at selected sites on Wilpinjong Creek.

Remediation and revegetation works have commenced along Wilpinjong Creek, using local native riparian woodland species. Further works are planned for both Wilpinjong and Cumbo creeks and should include areas susceptible to further lateral erosion.

6. References

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Appendix A – BEHI Assessment Scoring

Indicator	Measure	Score
1. Bank Height (m)	0 - 1.5	0
	1.5-3	2.5
	3-4.5	5
	4.5-6	7.5
	6+	10
2. Bank Angle (°)	0-20	0
	21-60	2
	61-80	4
	81-90	6
	91-120	8
	> 120	10
3. Percentage of Bank Height with a Bank Angle Greater than 80°	0-10	0
	11-25	2.5
	26-50	5
	51-75	7.5
	76-100	10
4. Evidence of Mass Wasting (% of Bank)	0-10	0
	11-25	2.5
	26-50	5
	51-75	7.5
	76-100	10
5. Unconsolidated Material (% of Bank)	0-10	0
	11-25	2.5
	26-50	5
	51-75	7.5
	76-100	10
6. Streambank Protection (% of Streambank covered by plant roots, vegetation, logs, branches, rocks etc	0-10	15
	11-25	12.5
	26-50	10
	51-70	7.5
	70-90	2.5
	90-100	0
7. Established Beneficial Riparian Woody - Vegetation Cover	0-10	15
	11-25	12.5

Indicator	Measure	Score
	26-50	10
	51-70	7.5
	70-90	2.5
	90-100	0
8. Stream Curvature Descriptor	Meander	5
	Shallow Curve	2.5
	Straight	0
Site Ratings (totals)	Highly Stable	0-25
	Mod Stable	26-35
	Stable	36-45
	Unstable	46-55
	Mod Unstable	56-65
	Highly Unstable	66-85

Appendix B – Site Photo Comparisons

Figure B - 1: WCk1 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 2: WCk2 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 3: WCk3 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 4: WCk4 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 5: WCk5 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 6: WCk6 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 7: WCk7 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 8: WCk8 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 9: WCk9 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 10: WCk10 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 11: WCk11 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 12: WCk12 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 13: WCk13 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 14: WCk14 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 15: WCk15 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 16: WCk16 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 17: WCk17 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 18: WCk18 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 19: WCk19 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 20: WCk20 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 21: WCk21 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 22: WCk22 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 23: WCk23 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 24: WCk24 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 25: WCk25 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 26: WCk26 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 27: WCk27 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 28: WCk28 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 29: WCk29 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 30: WCk30 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 31: WCk31 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 32: WCk32 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 33: WCk33 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 34: WCk34 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 35: WCk35 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 36: WCk36 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 37: WCk37 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 38: WCk38 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 39: WCk39 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 40: WCk40 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 41: WCk41 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 42: WCk42 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 43: WCk43 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 44: WCk44 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 45: WCk45 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 46: WCk46 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 47: WCk47 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 48: WCk48 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 49: WCk49 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 50: CCk1 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 51: CCk2 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 52: CCk3 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 53: CCk4 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 54: CCk5 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 55: CCk6 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 56: CCk7 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2018 upstream

Figure B - 57: CCk8 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 58: CCk9 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Figure B - 59: CCk10 site photos clockwise from top left: 2019 upstream, 2019 downstream, 2018 downstream, 2017 downstream, 2017 upstream, 2018 upstream

Appendix C – Monthly Rainfall Data

Table 9: Monthly rainfall from 2014 - 2019 (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2014	15.6	60.0	112.6	62.8	13.8	29.8	28.6	28.8	14.6	15.4	24.4	126.7	533.1
2015	127.6	11.6	9.4	108.4	42.8	42.8	38.0	53.8	7.8	61.0	59.0	118.4	680.6
2016	152.1	7.2	23.5	14.8	66.8	104.2	101.1	40.9	198.7	86.6	51.9	90.6	938.4
2017	27.8	34.2	146	23	32.4	10.4	5.8	25.2	3	28.4	92.6	102.6	531.4
2018	24.4	77	24.6	42.2	12.4	21.6	1.2	43.8	39.6	56.8	47.4	91.2	482.2
2019	54.8	7.4	108.8	0	17.6	10.6	2.6	10.2	23	5.6	22	3	265.6
Historical Mean	66.5	61.9	53.0	38.7	37.5	43.8	41.9	40.8	41.2	50.7	55.7	66.9	647.7

SOURCE: WCPL AND BUREAU OF METEOROLOGY, 2017 (HISTORICAL AVERAGES) WOLLAR (BARRIGAN STREET) WEATHER STATION NUMBER: 62032

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Wilpinjong Coal Mine Stream Health Monitoring – Spring 2019

Wilpinjong Coal Pty Ltd

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DOCUMENT TRACKING

Project Name	Wilpinjong Coal Mine Stream Health Monitoring – Spring 2019
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Project Manager	Kalya Abbey
Prepared by	Kate Maslen, Tom Kelly
Reviewed by	Dr Peter Hancock
Approved by	Daniel Magdi
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Template 2.8.1

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Abbreviations

Abbreviation	Description
ANZECC	Australian and New Zealand Environment and Conservation Council
AUSRIVAS	Australian River Assessment System
DO	Dissolved oxygen
EC	Electrical conductivity
EIS	Environmental Impact Statement
ELA	Eco Logical Australia
EPL	Environment Protection Licence
LGA	Local Government Area
MWRC	Mid Western Regional Council
NP	National Park
RCE	Riparian, Channel and Environment
SHM	Stream Health Monitoring
SIGNAL	Stream Invertebrate Grade Number Average Level
SWMMP	Surface Water Management and Monitoring Plan
WCM	Wilpinjong Coal Mine
WCPL	Wilpinjong Coal Pty Ltd

Summary of key findings

Stream health monitoring was undertaken during spring 2019 within the Wilpinjong Coal Mine (WCM) surrounding catchments. A total of twelve (12) permanent sites were monitored along Wilpinjong, Wollar and Cumbo creeks, however, only four (4) sites were able to be monitored for water quality and macroinvertebrates, due to low water levels.

The aquatic habitat assessment recorded mid-range scores, typical of catchments in the region. Results were largely consistent with previous years, with minor differences attributable to changes in stream bed macrophyte and groundcover, as a result of fluctuating water levels and climatic conditions.

Water quality results were poor and reflected the low water level and lack of flow present at each monitoring site sampled in 2019. This resulted in high temperature, electrical conductivity and turbidity results and low dissolved oxygen results, comparative to previous assessment years and Australian and New Zealand Environmental and Conservation Council (ANZECC) guidelines. Water quality results are consistently outside of ANZECC guidelines and fluctuate considerably across monitoring periods, stream flow levels and at various sites upstream and downstream of the WCM licensed discharge point. As such, these results indicate that natural factors rather than mining operations are key factors determining water quality in the catchments surrounding the WCM.

Macroinvertebrate results recorded in 2019 were poor, with overall low taxa diversity and low SIGNAL scores, indicative of pollution. SIGNAL scores were the lowest recorded for all sites surveyed in 2019(excluding WO2), however; do not trigger further investigation under Section 5.3 of the WCPL Surface Water Management and Monitoring Plan (WCPL, 2017a). The comparison of previous years data for sites surveyed in 2019 shows a decline in SIGNAL scores since 2017, coinciding with a prolonged period of below average rainfall, regional drought subsequently leading to a decrease or minimal stream flow. This pattern was observed both upstream and downstream of the WCM licensed discharge point, indicating that climatic factors along with past and present agricultural practices are the attributing main factors influencing stream health.

A revegetation program involving the planting of native riparian species has commenced within Wilpinjong Creek. The continuation of this program, along with the addition of in-stream retention devices such as large-woody debris, are worthwhile restoration works, aimed at improving the stream health of the catchments surrounding the WCM.

1. Introduction

1.1 Background

Eco Logical Australia (ELA) was engaged by Wilpinjong Coal Pty Ltd (WCPL) to undertake annual stream health monitoring (SHM). WCPL are required to undertake SHM to satisfy the updated requirement of Development Consent SSD 6764 Condition 29 & 30 (ii) (previously under Schedule 3, Condition 32 of WCPL's Project Approval (05-0021)) and the SHM criteria detailed in Appendix 2 of the Wilpinjong Water Management Plan (WCPL 2017).

1.2 Regional overview

The Wilpinjong Coal Mine (WCM) is located in the Mid-Western Regional Council Local Government Area, approximately 45 km north-east of Mudgee. The mine is owned and operated by WCPL, a wholly owned subsidiary of Peabody Energy Australia.

WCM is located at the headwaters of the Goulburn River which is a major tributary of the Hunter River catchment. Wilpinjong Creek is the main drainage channel within the WCM. It is an intermittent creek with a narrow floodplain that has a history of cattle grazing. The northern edge of the floodplain is bordered by the sandstone escarpments of Goulburn River National Park (NP). Wilpinjong Creek has three coal mines in its catchment, Moolarben, Ulan, and Wilpinjong, with the latter positioned furthest downstream. WCPL discharges water, treated by reverse osmosis, into Wilpinjong Creek at Environment Protection Licence (EPL) point 24 (EPL 24) directly adjacent to WCM.

Cumbo Creek flows north through land managed by WCPL, passing between Pit 3 and Pit 4, before joining Wilpinjong Creek north of the eastern pit area. Wilpinjong Creek continues to flow east, for approximately 4.5 km downstream where it joins Wollar Creek, which continues another 13 km through the Goulburn River NP before entering the Goulburn River.

1.3 Previous aquatic ecology assessments

A baseline aquatic assessment was undertaken for the Wilpinjong Coal Project Environmental Impact Statement (EIS) (BIO-ANALYSIS, 2005). The assessment found that aquatic habitats were in very poor condition and generally reflected the degraded nature of their immediate catchments with poor water quality, degraded riparian vegetation with low diversity and abundance of macroinvertebrates.

Annual SHM was conducted in 2006, 2008 and 2009 (Roberts, 2006; 2008; 2009), and from 2011 to 2013 (Landline Consulting, 2011; 2012; 2013). During these periods, water quality was generally outside the Australian and New Zealand Environmental and Conservation Council (ANZECC) guidelines and pollution-tolerant macroinvertebrate families dominated the aquatic community. Monitoring results found no evidence of any adverse impacts on the aquatic environment resulting from mining operations.

BIO-ANALYSIS (2015) undertook an aquatic ecology assessment for the Wilpinjong Extension Project (WEP) which found that the aquatic environment remained in a highly degraded state. The assessment concluded that the proposed Project would have minimal direct impacts on aquatic ecology and potential impacts downstream of the Project would be minimised with a number of existing mitigation measures already implemented at WCM.

Annual SHM recommenced in 2017 (ELA, 2017; 2018). Monitoring results from the 2017 assessment, showed an overall improvement of water quality measures and stream invertebrate grade number average level (SIGNAL) scores. Prolonged drought conditions between the 2017 and 2018 surveys resulted in an increase in dry sites observed which could not be surveyed, along with a reduction in water quality and SIGNAL scores at sites which were surveyed. Drought conditions with well-below average rainfall have continued in the period between the 2018 and 2019 surveys.

1.4 Objectives

The ongoing SHM program for WCM is aimed to assist in determining the need for any maintenance and/or contingency measures. The objectives of annual SHM of locations in Wilpinjong, Cumbo and Wollar Creeks include:

- Survey of aquatic macroinvertebrate assemblages in Spring if streamflow or ponded water is present and access to the creeks is safe, paired with in situ surface water quality sampling at each sampling site
- An assessment of environmental condition at each site based on a variety of ecological indices
- Comparisons of site indices against previous survey data to assess changes through time, and comparisons to trigger levels that would prompt further investigation.

2. Methodology

2.1 Survey overview

The 2019 SHM was undertaken by ELA ecologists Tom Kelly and Elise Keane on 19 to 20 November 2019. All 13 permanent monitoring sites specified in Appendix 2 of the WCPL Water Management Plan (WCPL 2017a) were included. This included two sites along Cumbo Creek, three sites along Wollar Creek, and eight sites along Wilpinjong Creek **(**Table 1**,** Figure 1**)**. Only four sites (WC1, WO1-3) contained water and were surveyed using the full SHM methodology. Of these sites, WC1, is located upstream of the WCPL licensed discharge point, whilst sites W01, W02 & WO3 are located on Wollar Creek which is a tributary of Wilpinjong Creek all of which sites are downstream the WCPL licensed discharge point.. Photographs of each site are included at Error! Reference source not found..

Table 1: 2019 monitoring sites

Creek	Site	Inundation Status	Easting	Northing
Wilpinjong Creek	WC1	Wet	767680	6422970
	WC2	Dry	768490	6422490
	WC3	Dry	770080	6420730
	WC4	Dry	772270	6420330
	WC5	Dry	773980	6420420
	WC6	Dry	774580	6420860
	WC7	Dry	775100	6421060
	WC8	Dry	775860	6420820
Cumbo Creek	CC1	Dry	772710	6418130
	CC2	Dry	772980	6418950
Wollar Creek	WO1	Wet	777940	6418170
	WO2	Wet	777780	6418950
	WO3	Wet	777790	6420100

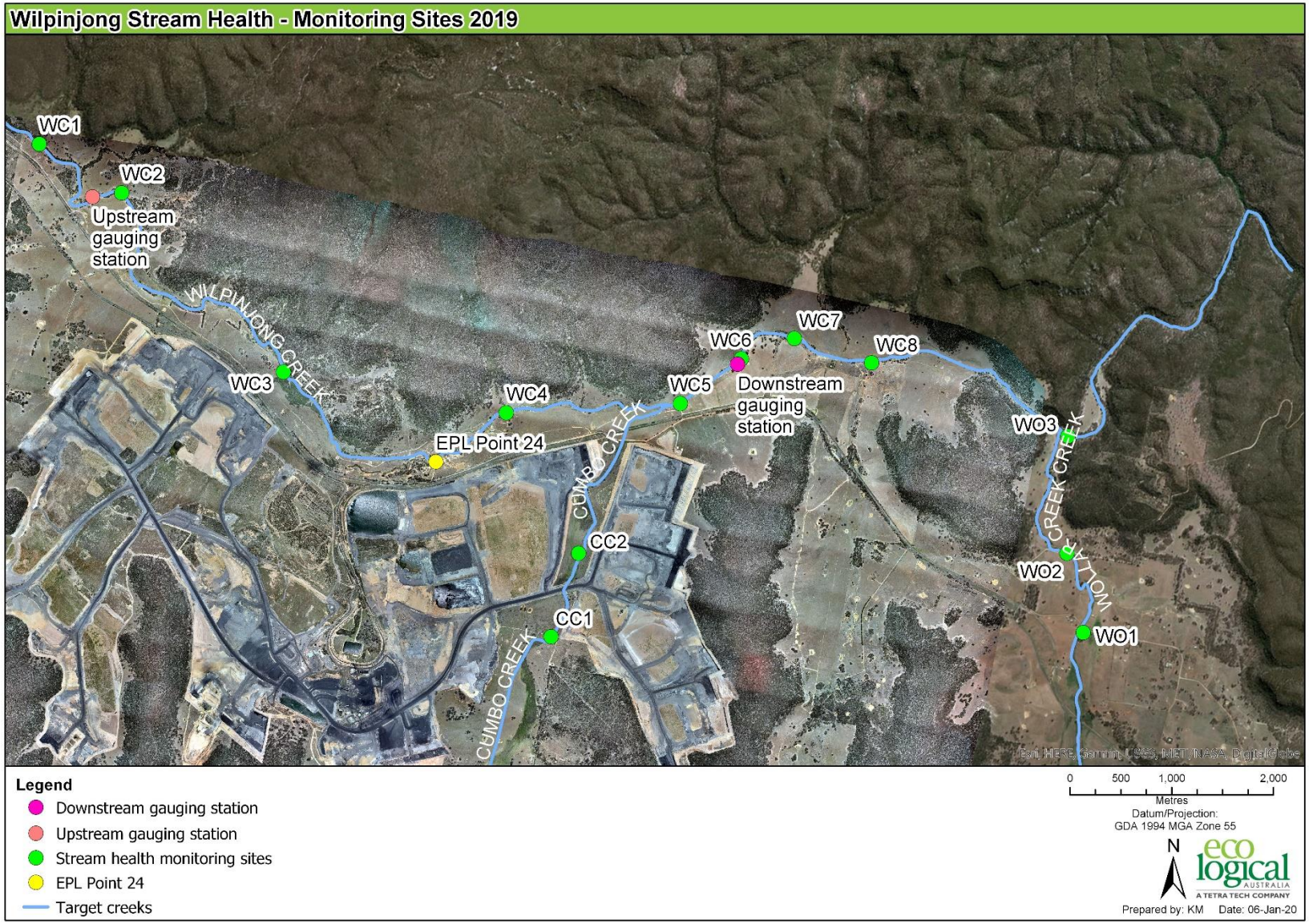

Figure 1:Monitoring sites along Wilpinjong, Wollar and Cumbo Creek

2.2 Survey methods

2.2.1 Aquatic habitat assessment

Aquatic habitat assessments were based on the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI Fisheries 2013), which outlines the features important for fish habitat in freshwater, estuarine, and marine areas. Habitat assessments allow the significance of river reaches to be determined, regardless of whether target fish species are present permanently, or for brief periods of time.

Aquatic habitat variables (environmental data) were noted for each site, with observations made from the bank on the following characteristics:

- General signs of disturbance
- Habitat type
- Channel topography
- Current water level
- Bank and bed slope
- Degree of river shading
- Amount of detritus
- Macrophyte type and extent
- Riparian zone width
- Snags and large woody debris coverage
- Stream width and depth
- Surrounding land use
- Description of the natural substrate
- Extent of bank overhang
- Amount of trailing bank vegetation.

Riparian condition was assessed using a version of the Riparian, Channel and Environmental (RCE) inventory (Peterson 1992) that was modified for Australian conditions (Chessman *et al*. 1997). The modified RCE has 13 descriptors, each with a score from one (poor condition) to four (good condition).

Descriptors included width and condition of the riparian zone, surrounding land use, extent of bank erosion, stream width, water depth, occurrence of pools, riffles and runs, sub-stratum type, presence of snags and woody debris, in-stream and emergent macrophytes, algae, and barriers to fish passage. The total score for each site was derived by summing the score for each descriptor and calculating the result as a percentage of the highest possible score (up to 52).

Sites with a high RCE score indicate that the riparian zone is largely undisturbed, while those with a low score have undergone substantial modification. Based on the original classification established by Peterson (1992), site condition was rated as follows:

- Poor for RCE scores of 0-24%
- Fair for RCE scores of 25-43%
- Good for RCE scores of 44-62%

- Very Good for RCE scores of 63-81%
- Excellent for RCE scores of 82-100%.

RCE results from 2019 were compared with previous years results dating to 2016, when RCE was introduced to the WCPL SHM program (**Section 4.1**).

2.2.2 Water quality

Complementing documented biological data, physicochemical parameters were measured where sufficient water was present. Temperature, dissolved oxygen (DO), electrical conductivity (EC) and pH were measured with a YSI-556 meter, which was calibrated prior to the field survey. The DO probe was calibrated at the start of each survey day. Turbidity was measured with a Hach 2100Q Turbidimeter. Water quality results from 2019 were compared with previous year's results for DO, EC and turbidity (**Section 4.2**). Results date back to 2006, however, not all parameters have results available for each year.

2.2.3 Macroinvertebrate communities

Where sufficient water was present, macroinvertebrate samples were collected at each site using the Australian Rivers Assessment System (AUSRIVAS) protocols (Turak *et al*. 2004). Samples were collected from 10 m of representative edge, pool or riffle habitats using a standard AUSRIVAS kick net with 250 µm mesh. The net was bounced along the bottom to disturb resting invertebrates, and then rapidly passed again through the water column to collect them. Edge habitats were defined as adjacent to the creek bank in areas of little or no flow, including alcoves and backwaters, with abundant leaf litter, fine sediment deposits, macrophyte beds and overhanging bank vegetation (Turak *et al*. 2004).

Macroinvertebrate samples were live-sorted in the field for a minimum of 40 minutes. If new taxa were collected in the period from 30 to 40 minutes, picking continued for 10 minutes. If no new taxa were found after the additional 10 minutes, sorting stopped. The maximum sorting time was 60 minutes. All picked animals were preserved in 70% ethanol solution and transferred to the laboratory for identification. Specific care was taken to ensure cryptic, fast moving taxa were represented.

Macroinvertebrates were identified to family level, except for *Oligochaeta, Platyhelminthes* and *Ostracoda* which were identified to order.

The Stream Invertebrate Grade Number - Average Level (SIGNAL) is a biotic index that allocates a value to each macroinvertebrate family based upon their sensitivity to pollution. A macroinvertebrate family with a value of ten indicates high sensitivity, while a value of one indicates low sensitivity (i.e. high pollution tolerance) (Chessman *et al*. 1997). The SIGNAL score for the entire site is calculated by summing the SIGNAL grades for each family collected at that site and then dividing by the total number of families collected. SIGNAL scores are used to grade aquatic health into the following categories:

- SIGNAL Score > 6: Healthy Habitat
- SIGNAL Score 5-6: Mild Pollution
- SIGNAL Score 4-5: Moderate Pollution
- SIGNAL Score < 4: Severe Pollution.

Average SIGNAL scores for 2019 were compared with scores from previous years, dating back to 2006 (where available) (**Section 4.3**). SIGNAL scores from 2011 to 2013 (Landline Consulting, 2011; 2012; 2013) were calculated using abundance weighting of macroinvertebrate taxa which resulted in slightly higher average SIGNAL scores for sites with relatively abundant macroinvertebrates. Whilst this method differs slightly from that undertaken in previous years, the results are largely consistent and valid for comparison.

2.3 Climate and flow data

During the two days of monitoring, the temperature was hot, with no rainfall recorded (**Table 2**). In the six months preceding the survey, temperatures were above the historical mean, whilst rainfall was well below the historical mean, indicative of the prolonged drought conditions experienced across the region (**Table 3**).

Table 2: Temperature and rainfall data for the Spring 2019 monitoring period

Date	Min. temp (°C)	Max. temp (°C)	Rainfall (mm)
29 Nov 2018	15.6	35	0
30 Nov 2018	17.8	34	0

Source: WCPL Weather Station Sentinex 34

Table 3: Temperature and rainfall data for the six months prior to monitoring

Month	2019			Historical means		
	Mean min. temp (°C)	Mean max. temp (°C)	Total Rainfall (mm)	Min. temp (°C)	Max. temp (°C)	Rainfall (mm)
Nov 2019	13.4	29.6	22	11.3	26.5	55.7
Oct 2019	9.5	27	5.6	7.7	23.2	50.7
Sep 2019	5.1	22.7	23	4.3	19.7	41.2
Aug 2019	1.7	18.3	10.2	1.5	16.3	40.8
July 2019	2.8	17.2	2.6	1.1	14.5	41.9
June 2019	2.6	16.6	10.6	2.3	15.0	43.8

Source: 2019 data from the WCPL Weather Station Sentinex 34, historical data from the BoM weather stations at Mudgee Airport (temp) and Wollar (Barrigan St) weather station (rainfall)

Flow levels in Wilpinjong Creek since 2012 have averaged 2.7 ML/day downstream and 0.9 ML/day upstream of the WCPL licensed discharge point. Flow has drastically receded at both gauging stations since early 2017, with no flow recorded at the upstream gauging station and only 2.7 ML recorded at the downstream gauging station during 2019, indicative of prolonged drought conditions and the cessation of water discharge since November 2018 (

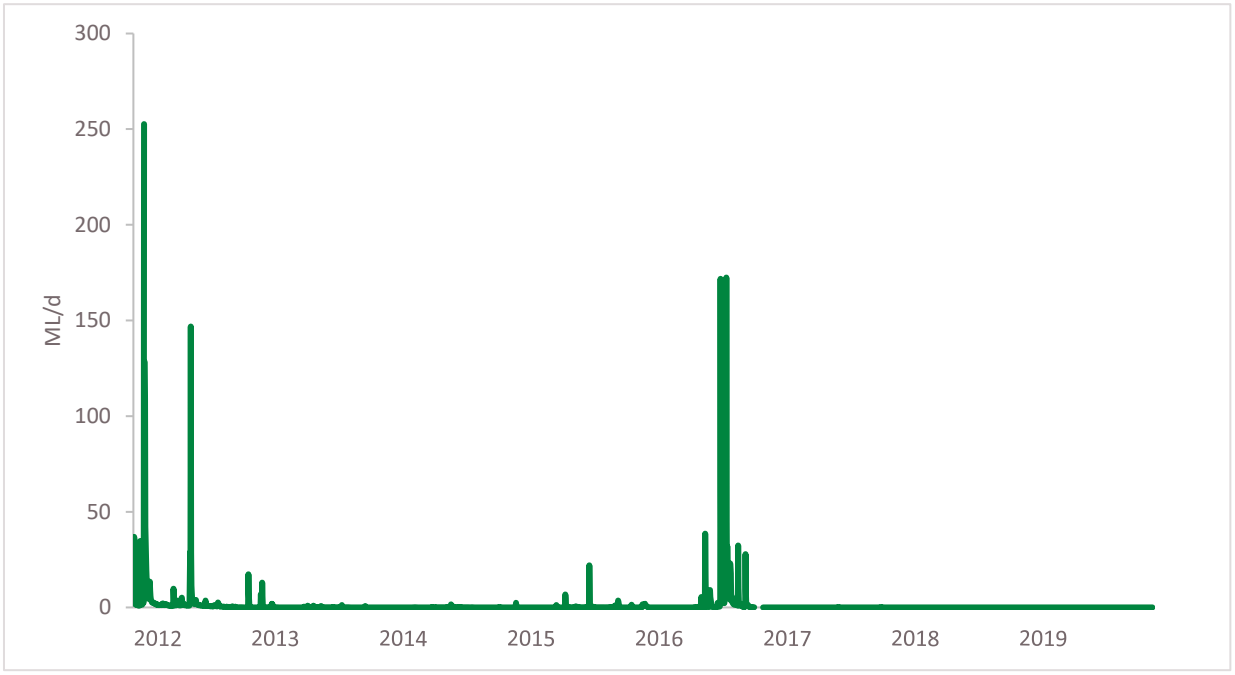

Figure 2 **and**

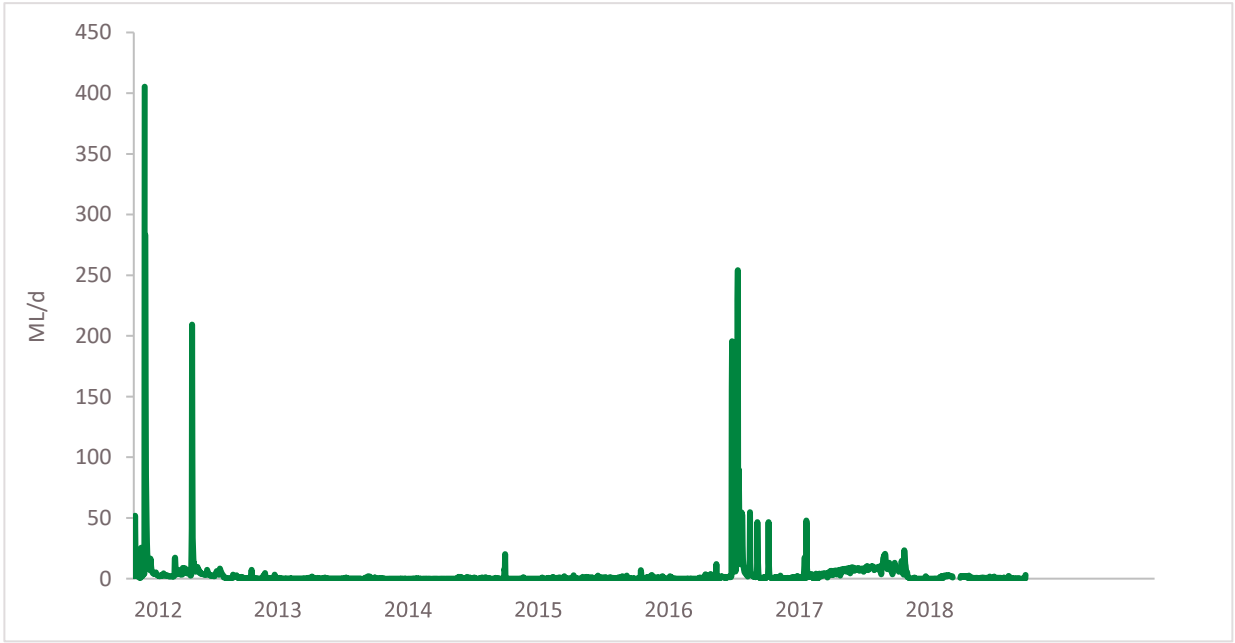

Figure 3).

Figure 2: Stream flow upstream of the WCPL mine discharge point EPL 24

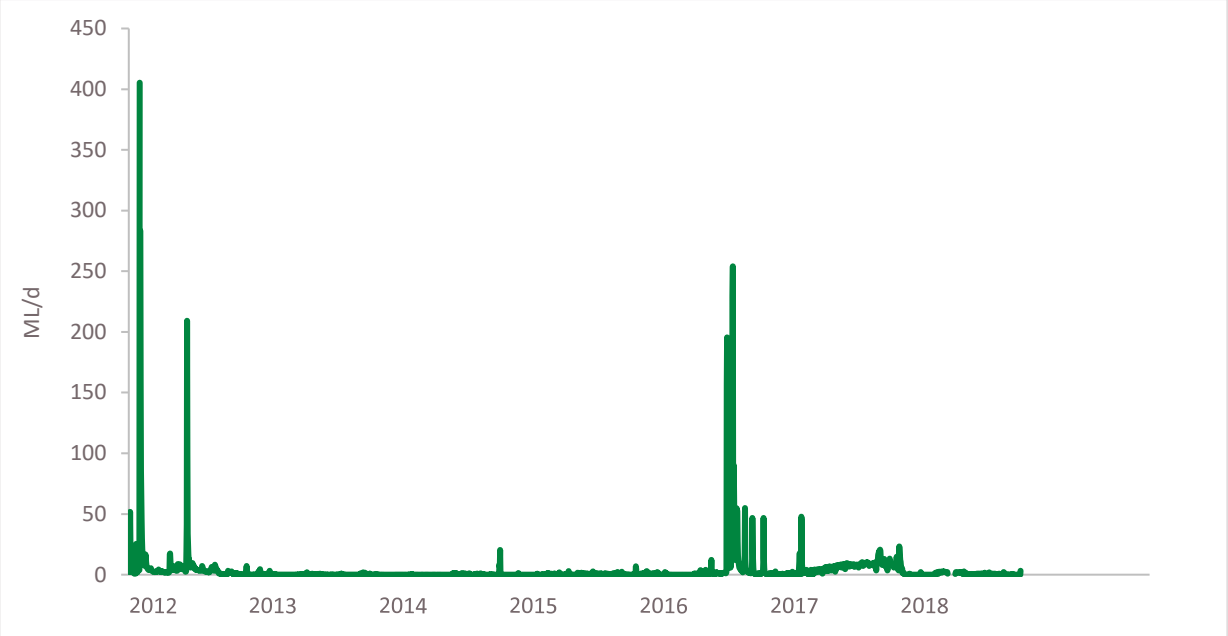

Figure 3: Stream flow downstream of the WCPL mine discharge point EPL 24

3. Results

3.1 Aquatic habitat assessment

Results of the habitat assessment, including water, substrate, vegetation, land use, and how these elements contribute to the RCE score are detailed below. A breakdown of how the 13 RCE parameters scored for each site is included in Table 4: Site results for the 13 RCE parameters.

Table 4: Site results for the 13 RCE parameters

Descriptor	WC1	WC2	WC3	WC4	WC5	WC6	WC7	WC8	WO 1	WO 2	WO 3	CC 1	CC 2
Land use pattern beyond immediate riparian zone	3	3	3	3	2	2	2	3	2	3	3	2	3
Width of riparian strip of woody vegetation	3	3	3	3	1	3	3	3	3	3	3	2	1
Completeness of riparian woody strip of vegetation	2	2	2	2	1	2	2	3	2	2	2	1	1
Vegetation of riparian zone within 10 m of channel	4	4	2	3	2	2	2	2	3	3	3	2	1
Stream bank	2	2	3	3	3	3	3	3	2	3	3	3	3
Bank undercutting	3	3	4	4	3	3	3	4	3	3	3	4	4
Channel form	2	3	3	3	3	3	3	3	3	3	3	2	3
Riffle/pool sequence	2	3	3	3	3	3	3	3	3	3	3	2	2
Retention devices in stream	1	1	1	1	1	1	2	2	4	4	3	1	1
Channel sediment accumulations	4	3	2	4	4	4	4	4	2	3	3	4	4
Stream bottom	1	2	2	2	2	2	3	1	3	1	2	2	1
Stream detritus	1	3	2	3	2	2	2	2	2	3	3	2	2
Aquatic vegetation	2	4	2	2	2	4	4	2	1	2	2	2	4
Total	**30**	**36**	**32**	**36**	**29**	**34**	**36**	**35**	**33**	**36**	**36**	**29**	**30**
Total %	**57.7**	**69.2**	**61.5**	**69.2**	**55.8**	**65.4**	**69.2**	**67.3**	**63.5**	**69.2**	**69.2**	**55.8**	**57.7**
Condition classification	**G**	**VG**	**G**	**VG**	**G**	**VG**	**VG**	**VG**	**VG**	**VG**	**VG**	**G**	**G**

G = Good; VG = Very Good

Site WC1

This site is upstream of WCM and has a thin patch of riparian woodland on both banks, with cleared pasture in the floodplain beyond. The stream bank is approximately 20 m wide and rises 1.5 to 2m above the bed. There is an artificial dam present that has retained a small amount of runoff. There was

less water present at this site compared to 2018, with water restricted to an isolated pool with no flow. There was evidence of turbidity, plume, sediment oils and anaerobic odours during visual inspection, indicating poor water quality.

Riparian vegetation consisted of mature and juvenile *Angophora floribunda* (Rough-barked Apple) and *Eucalyptus blakelyi* (Blakely's Red Gum) trees. The dominant shrub species was *Cassinia arcuata* (Sifton Bush). The vegetation present is predominantly comprised of native species. There were previously dense stands of *Phragmites australis* (Common Reed) along the creek bed, however, prolonged dry conditions have resulted in considerable dieback of this species, with dense litter accumulating as a result in the creek bed.

This site scored an RCE score of 57.7%, indicating that the riparian and channel condition is rated as 'Good'.

Site WC2

WC2 was dry when visited during November 2019. The northern bank of Wilpinjong Creek is severely eroded above a shelf of horizontal bedrock strata. The bank is approximately 20 m wide, with a height of 1.5 m. The site sits amongst cleared pasture, with a thin patch of riparian woodland on the southern bank.

The dominant riparian vegetation included Rough-barked Apple and *Eucalyptus melliodora* (Yellow Box). All vegetation species within the site were native. There was 50% bare ground above the watermark which may impact bank stability during high flow events. No macrophytes are present within the dry stream bed, with small woody debris forming the only stream retention devices.

The site scored an RCE index of 69.2%, which places it in the 'Very Good' category.

Site WC3

WC3 was dry when visited during November 2019. The bank is 15 m wide and stood approximately 1.5 m above the sandy stream bed. The southern bank abuts cleared pasture, whilst beyond the northern bank is regenerating native woodland. The channel banks are surrounded by *Phragmites australis* and parts of the channel bed. The dominant riparian vegetation beyond the northern bank includes Rough-barked Apple and Blakely's Red Gum.

This site had an RCE score of 69.2% and is classified as being in 'Very Good' condition. There was no bank undercutting at the site, due to the gentle slope and sandy substrate.

Site WC4

This site was dry when visited during November 2019. The bank is 30 m wide and 3 m high. Along the southern bank, the land use was cleared pasture, whilst a very think strip of riparian woodland was present on the northern bank. The northern bank has undergone considerable historic erosion, however, its lower slope is being stabilised by regenerating Rough-barked Apple.

Bedrock made up 15% of the site and was a dominant substrate within the creek, along with sand and silt. The central section of the creek bank had enough sediments to support stands of *Phragmites australis* and *Typha orientalis* (Cumbungi), although the stands are dying back.

This site scored 73.1% in the RCE index, so is classified as 'Very Good'. This site had the highest score out of all sites. The number of rock and log retention devices in the stream scored low, although stands of macrophytes scattered along the bed could perform a similar function.

Site WC5

This site was dry during the time of surveying in November 2019. The bank is 25 m wide, with an average bank height of 2 m. The site is surrounded by cleared pasture on both banks. The stream bed is dominated by *Typha orientalis*, while along the bank there is *Lomandra confertifolia* (Mat-rush) and *Aristida ramosa* (Purple Wiregrass).

WC5 scored 55.8% in the RCE index, meaning it is classified as 'Good'. There was very no woody vegetation in the riparian zone, with both banks historically cleared. Dense stands of macrophytes would act as in-stream retention devices in during low to moderate flows.

Site WC6

This site was dry during the November survey. Site WC6 has a small weir at the western (upstream) end of the reach. Downstream of the weir the stream flows across bedrock and compacted sand and silt. There is cleared mixed pasture along both sides of the creek, with mature trees on both upper banks. The width of riparian woodland increases downstream of the reach. The width of the bank is 15 m with a 1.5 m high bank.

The southern bank has some exposed rock ledges and a short rocky side arm. The dominant riparian vegetation is Blakely's Red Gum*, Eucalyptus melliodora* (Yellow Box), *Eucalyptus albens* (White Box) and *Lomandra confertifolia*. Stands of macrophytes previously within the bank have died off, with a low cover of mixed native and exotic forbs and grasses now in the channel.

The site scored 65.4% in the RCE index, giving it a classification of 'Very Good'.

Site WC7

This site was dry when visited during November 2019. The creek bank at this site is 20 m wide and 2 m in height and of a low to moderate slope. Both banks were well vegetated with scattered Blakely's Red Gum, Rough-barked Apple and Yellow Box and predominantly native ground cover. Ground cover within the stream is sparse and comprised of both native and exotic species, with evidence of cattle (pats and hoof prints) accessing the stream bed. Bedrock forms much of the upstream portion of the stream bed, with minor woody debris active as in-stream retention devices.

WC7 scored 69.2% for the RCE index, giving it a classification of 'Very Good'.

Site WC8

This site was dry during the time of surveying in November 2019. The creek bank is 1 m high and 15 m wide. The land use on both sides of the creek is agricultural, with a thin strip of riparian woodland on the southern bank, while the northern bank immediately becomes pasture. Both banks are gently sloping, with sedimentary bedrock exposed on the southern bank.

Woodland riparian vegetation on the southern bank includes scattered Blakely's Red Gum, Rough-barked Apple and *Eucalyptus albens* (White Box), with a sparse mixed native and exotic groundcover. Macrophytes which formerly covered the entire reach have died back and now form a dense layer of litter. Native grasses and mostly exotic forbs also form a low cover in the stream bank.

WC8 scored 67.3% for the RCE index, giving it a classification of 'Very Good'.

Site WO1

Site WO1 has a bank height of 2 m and bank width of 25 m. The site is intersected by a concrete causeway on Araluen Road. The land use along both sides of the bank is cleared pasture, with the upstream reach currently accessed by cattle. During the time of survey, the site formed one large isolated pool on both sides of the concrete causeway. There was less water present at this site compared to 2018, with no surface water flow. There was evidence of moderate turbidity, plume, sediment and water oils and anaerobic odours based on a visual inspection, indicating poor water quality.

During the time of sampling there was moderately dense stands *Typha orientalis* which has been partially grazed by cattle. The ground cover on the banks consists of both native and exotic species.

This site scored 63.5% for the RCE index, giving it a classification of 'Very Good'.

Site WO2

This site is on Wollar Creek, where the bank was 20 m wide and 2 m high. At the downstream end of the reach, the creek passes under Mogo Road, via a concrete causeway. There was less water at the site compared to 2018, with one large isolated pool on both sides of the concrete causeway. There was evidence of significant turbidity, plume, sediment and water oils and anaerobic odours based on a visual inspection, indicating poor water quality.

Both banks are predominantly cleared, with only scattered woody riparian vegetation present. The ground cover is comprised of mixed native and exotic species. A dense stand of *Typha orientalis* is present on the upstream section of the reach, with a portion grazed by cattle which were present within the site. Previously dense *Typha orientalis* in the downstream section of the reach has mostly died back.

WO2 scored 69.2% for the RCE index, giving it a classification of 'Very Good'.

Site WO3

This site is along Wollar Creek, approximately 100 m downstream of the confluence with Wilpinjong Creek. The site has a bank width of 20 m and bank height of 3 m. At the time of survey, the site comprised two isolated pools, with no surface water flow between the two pools. There was evidence of significant turbidity, plume, sediment and water oils and anaerobic odours based on a visual inspection, indicating poor water quality.

The land adjacent to both banks has been partially cleared but transitions into native remnant vegetation in the downstream section of the reach. There is a good canopy cover over the creek at this site, with overstory species Blakely's Red Gum, Rough-barked Apple and Yellow Box present. Around the pools previously dense *Typha orientalis* stands have mostly died back.

WO1 scored 69.2% for the RCE index, giving it a classification of 'Very Good'.

Site CC1

This site is located in Cumbo Creek which was dry at the time of sampling. The bank width is 10 m and bank height is 1.8 m. The site is intersected by a concrete creek-crossing which in times of water, dams

the upstream portion of the reach. 2019 is the first year in which this site has been completely dry since SHM began.

The land along both banks is comprised of pasture, with dense clumps of *Juncus* sp. present on both banks. The channel was contained a dense stand of *Typha orientalis* and *Cyperus* sp., however, these have since died back resulting in an accumulation of litter in the channel bed. A single *Eucalyptus conica* (Fuzzy Box) is located immediately upstream of the site.

This site scored 57.5% for the RCE index, giving it a classification of 'Good'.

Site CC2

This site was dry at the time of sampling. The bank width is 50 m and bank height is 0.5 m, with this section of Cumbo Creek forming a series of narrow channel on a low-energy broad floodplain. Woody riparian vegetation is extremely limited with only scattered Rough-barked Apple and *Eucalyptus conica* (Fuzzy Box) trees present. The groundcover is dense, comprised of both native and exotic species including *Juncus* sp. and *Paspalum dilatatum* (Paspalum). The density of ground cover within the channel and across the floodplain indicates that the site is predominantly dry across all seasons.

This site scored 57.7% for the RCE index, giving it a classification of 'Good'.

3.2 Water quality

The results of the water quality testing for temperature, EC, DO, pH and Turbidity are detailed below in Error! Reference source not found.. Note that there are no results for sites WC2, WC3, WC4, WC5, WC6, WC7, WC8, CC1 and CC2 as they were dry at the time of monitoring and no water samples could be taken.

Water temperatures at the time of sampling ranged between 20.5°C and 29.1°C. The warmest water was at site WO3, which was taken from a small pool and sampled in the afternoon.

EC was high in both Wilpinjong and Wollar Creeks. Site WC1, upstream of the WCPL licensed discharge point, had the highest value of 4835 µS/cm. All sites exceeded the ANZECC guideline for EC.

Dissolved oxygen ranged between 49% saturation at WC1 to 82.5% saturation at WO1. There were no sites in Wilpinjong and Wollar Creeks that were within the recommended ANZECC range. All sites had a pH between 7.52 and 7.88 which were within the ANZECC range.

Turbidity was high across all sites but within ANZECC guidelines at both WO1 and WO3. Turbidity at WC1 was well above guidelines, having been collected from a small, shallow isolated pool (Table 5: Physicochemical results).

Table 5: Physicochemical results

Variable	ANZECC Range	WC1	WO1	WO2	WO3
Temperature (°C)		20.5	26.26	26.18	29.11
Conductivity (µS/cm)	30-350	4835	4333	4452	4119
DO (% saturation)	90-110	49	82.5	75.4	64.9

Variable	ANZECC Range	WC1	WO1	WO2	WO3
DO (mg/L)		4.25	6.52	5.84	4.87
pH	6.5-8.0	7.52	7.54	7.82	7.88
Turbidity (NTU)	2-25	194	8.37	25.2	24.9

3.3 Macroinvertebrate communities

3.3.1 Taxa richness

A total of 16 macroinvertebrate orders, comprising 25 taxa families, were collected from the four sites sampled during 2019. Taxa richness was highest at WO2, with 21 taxa recorded, and lowest at WC1, with 16 taxa recorded. There were a total of five taxa that were recorded across all sites, three of which belong to the pollution tolerant order Hemiptera, whilst a total of eight taxa were only present at one site. Full macroinvertebrate data for each of the four sites surveyed in 2019 is provided in **Appendix B**.

3.3.2 SIGNAL

Pollution sensitivity ratings for each family/order were used to calculate the average SIGNAL score for each site. Where families/orders have no assigned SIGNAL sensitivity rating, they were not included in the averages, however, are still represented in results for taxa richness (see **section 3.3.1** above).

Average SIGNAL scores range from 2.33 at WC1 to 3.05 at WO2 (Table 6). All the sites had an average SIGNAL score of less than 4.0 and as such, are classified as severely polluted. Despite having an average SIGNAL score below 3.0, sites WC1, WO1 and WO3 recorded taxa richness in excess of 15. As such, these sites do not trigger further investigation, as per the interim performance conditions detailed in Section 5.3 of the WCPL Surface Water Management and Monitoring Plan (WCPL, 2017a).

Dixidae was the highest scoring taxa (7), however, was only recorded at site WO2. This is the only taxa recorded across all sites with a SIGNAL sensitivity rating indicative of healthy aquatic habitat. Additionally, of the 24 taxa recorded with a SIGNAL sensitivity rating, 14 were indicative of severe pollution.

Table 6: Results of the two macroinvertebrate indices

Measure	WC1	WO1	WO2	WO3
Taxa richness	16	18	21	18
Average SIGNAL score	2.33	2.93	3.05	2.93
SIGNAL pollution condition	S	S	S	S

S= Severe

4. Discussion

4.1 Aquatic habitat assessment

All sites received either 'Good' or 'Very Good' classification for their RCE indices. This puts them in the mid-range for riparian and channel habitat quality. Habitat conditions within Wilpinjong, Wollar and Cumbo Creek sites were largely consistent with those recorded in previous years, both upstream and downstream of the WCPL licensed discharge point (**Figure 4**). Temporal differences were largely restricted to changes in macrophyte and ground cover abundance (*Stream bank*) and water levels (*Stream bottom* and *Stream detritus*) (Table 4: Site results for the 13 RCE parameters). Compared to 2018, sites WC6, WC7, WC8 and CC1 were dry. This is a direct result of prolonged drought conditions with below average rainfall and increased average temperatures compared to historical means.

Lack of in-stream retention devices (*Retention devices in stream*) such as logs, and boulders were common at many sites, with scores of one or two for this attribute. This is typical of streams in agricultural landscapes as large debris have generally been removed, and woody riparian vegetation that would provide fallen branches and logs is limited. In-stream retention devices help slow the movement of flow, which in turn reduces the waters erosive power and contributes to of the local area. Retention devices are also important for the accumulation of coarse particulate organic matter, an important energy source for macroinvertebrate communities.

Similarly, the stream bed structure (*Stream bank*, *Stream bottom* and *Stream detritus*) also scored low overall, due to lack of vegetation cover and the presence of loose and mobile sediments along the stream bed at most sites. This is typical in a highly modified agricultural landscape where sites have reduced bank stability leading to increased erosion and sedimentation. Prolonged drought conditions, as well as historical and current stock access, has also contributed to low stream bed scores. These results suggest that climatic factors, along with agricultural activities, are the key factors influencing aquatic habitat as opposed to mining operations.

Figure 4: RCE scores across all sites and years

4.2 Water quality

Water temperature overall was quite high (average temperature 25.5°C), attributed to the small isolated pool sizes at each site along with minimal riparian shading and high ambient temperatures (34 – 35°C) during the survey. Given the above factors, the water temperature at each site is likely to fluctuate considerably. Increased water temperature decreases the ability to retain DO required to support aquatic organisms and is likely linked to the low DO concentrations recorded at each site.

DO concentrations were below ANZECC guideline range across all sites. DO concentrations can further fluctuate due to a range of factors including organic and bacterial activity, water flow, flow circulation and time of day. Low DO concentrations recorded in 2019 is likely due to a combination of these factors, as a result of the small isolated pools sampled, warm ambient temperatures and the absence of flow at each site. DO concentrations have fluctuated considerably across sites and years which are consistently outside ANZECC guidelines (**Figure 5**). These results have been recorded both upstream and downstream of the WCPL discharge point, which suggests DO concentrations and fluctuations are not linked to mining operations.

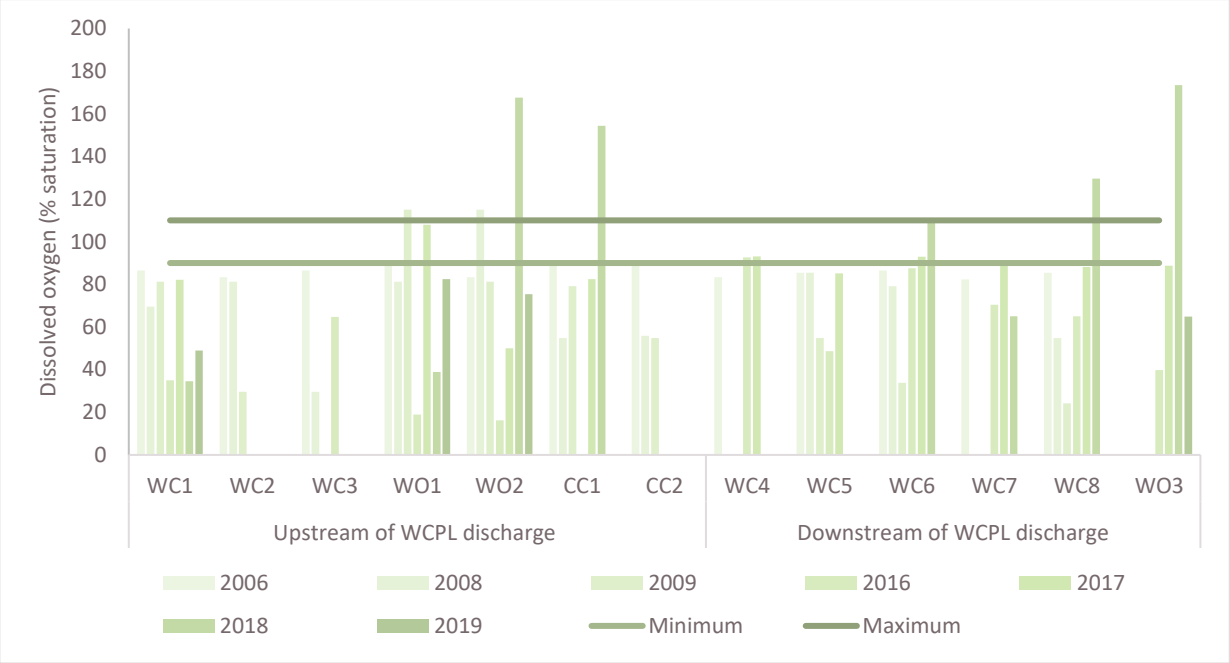

Figure 5: DO (% saturation) results across all sites and years

EC was above ANZECC guidelines at all sites surveyed in 2019. Whilst EC has varied considerably across all sites and all years, it has been consistently above ANZECC guidelines both upstream and downstream of the WCPL licensed discharge point (**Figure 6**). High EC results have also been recorded during periods of variable stream flow (

Figure 2 **and**

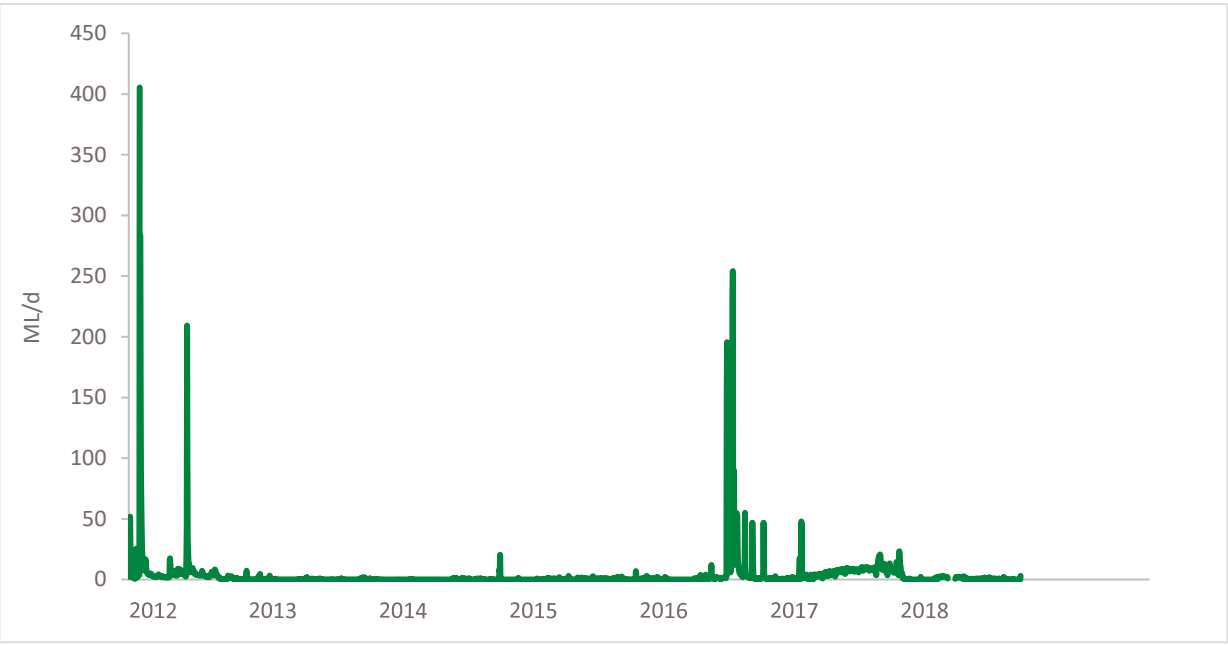

Figure 3), indicating the naturally saline nature of water and the general landscape within the local catchment.

Cross referencing the EC data from 2016 and 2018 SHM (ELA, 2017; ELA, 2019), with data from WCPL's monthly surface water monitoring data (WCPL, 2017b; WCPL, 2018) recorded at the licensed discharge

point at the same time, reinforces the natural occurrence of saline water in the catchment. EC recorded at the licensed discharge point in January 2017 and November 2018 average 294 µS/cm and 310 µS/cm respectively, which is significantly lower than those recorded during 2017 and 2018 SHM at upstream monitoring sites (**Figure 6**). Additionally, the SHM results show a general increase in EC at monitoring sites downstream from the licensed discharge location as the water travels further down the catchment. This comparison indicates that natural variables rather than mining operations are responsible for high EC concentrations.

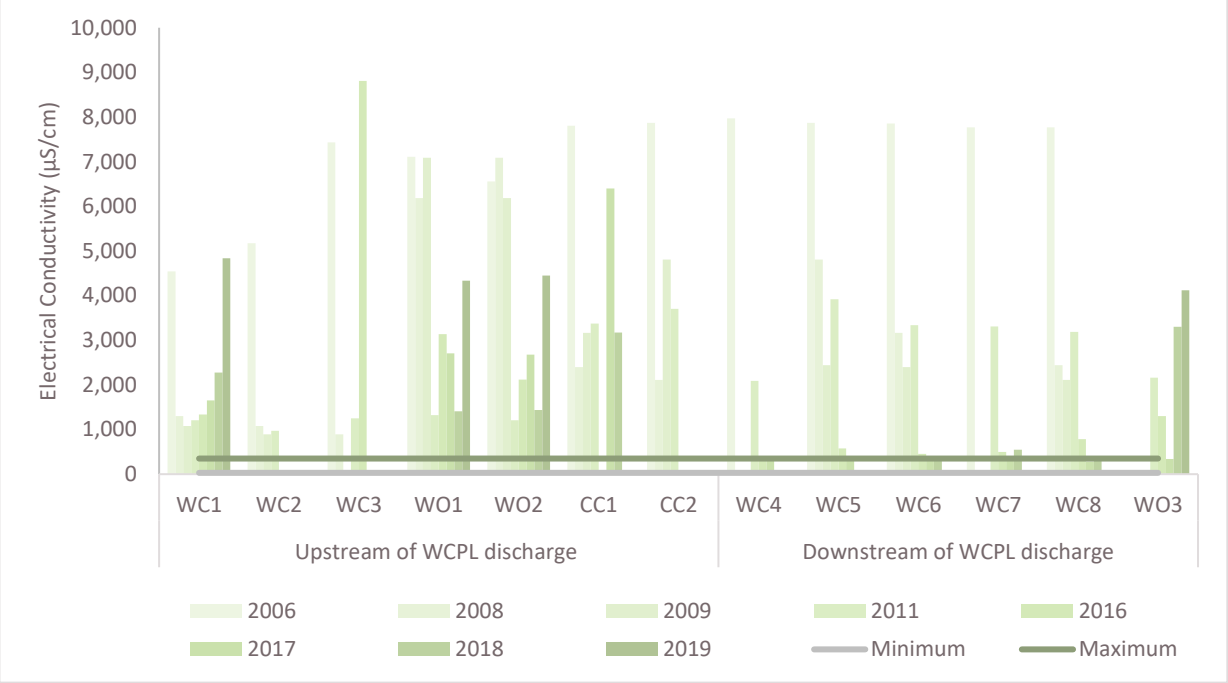

Figure 6: EC (µS/cm) results across all sites and years

Turbidity was high across all sites surveyed in 2019 (excluding WO1), with sites WC1 and WO2 outside ANZECC guidelines (2-25 NTU) and site WO3 only marginally within guidelines (24.9). In comparison to previous results, the 2019 Turbidity results for sites WC1, W02, W03 were the highest recorded to date (**Figure 7**). These results indicate the influence of dry, low flow conditions, as they result in increasingly small isolated pools at each site with corresponding increased turbidity. Continued stock access at sites WC1 and WO2 is also likely to have influenced the relatively high turbidity scores recorded at these sites during 2019. As such, there is no apparent link between high turbidity results recorded during 2019 and mining operations. WCM is permitted to discharge water from the Licenced Discharge Point, as per EPL 12425, with a NTU of 50. No exceedances were recorded in the 2019 calendar year and there was limited/no discharge offsite throughout the reporting period, therefore this discharge does not currently impact on the turbidity of the creeks.

The pH results for all SHM sites monitored during 2019 were within ANZECC guidelines (Figure 8).

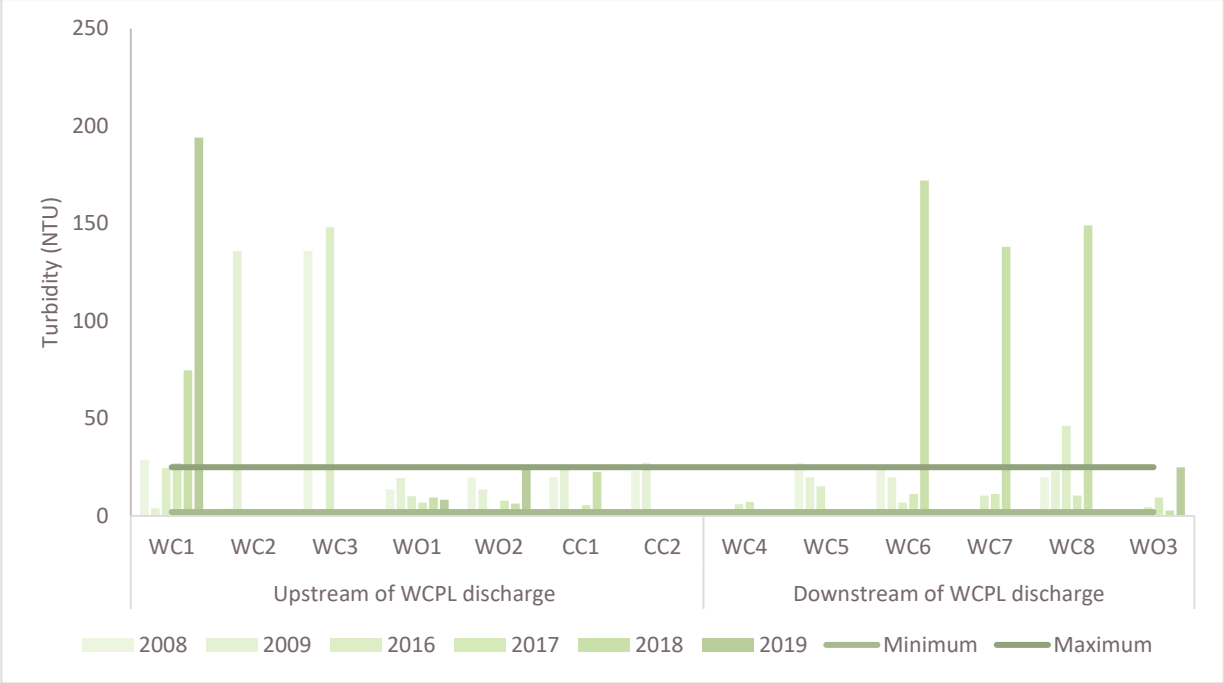

Figure 7: Turbidity (NTU) results across all sites and years

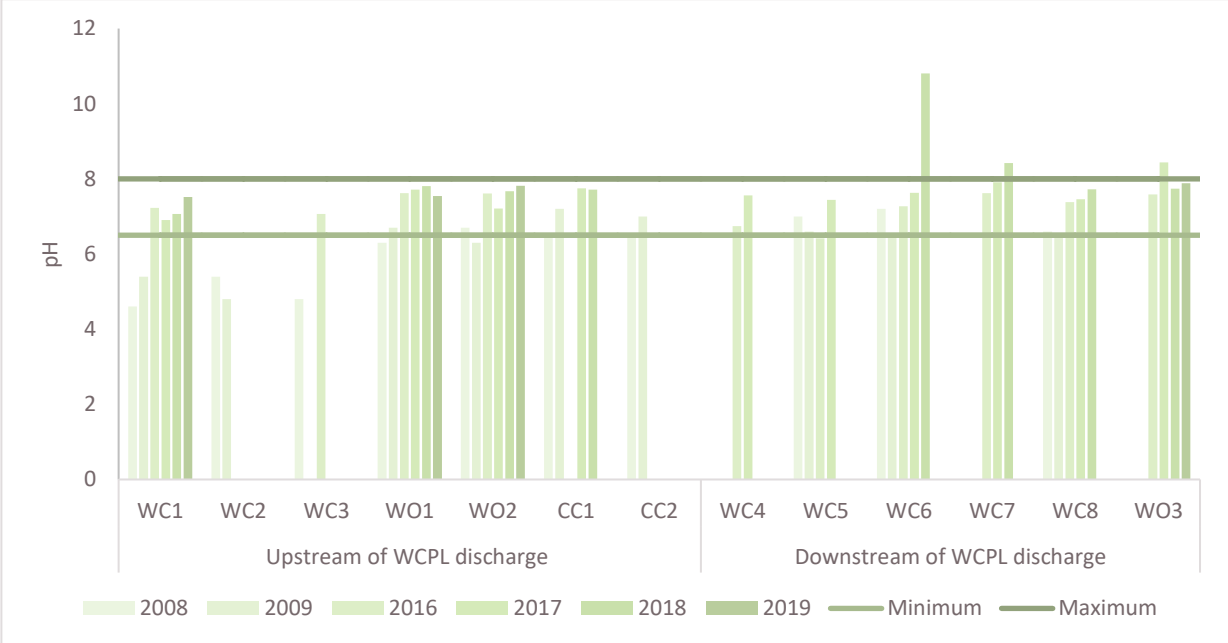

Figure 8: pH results across all sites and years

4.3 Macroinvertebrate communities

Across all twelve (12) monitoring sites surveyed as part of the WCPL SHM program, only three sites (WC2, WC4 and CC2) have an average SIGNAL score ≥4 and are therefore the only sites not classed as Severely polluted (being classed as Moderately polluted). These poor SIGNAL results have been recorded both upstream and downstream of the WCPL discharge point and reflect the overall disturbed

nature of the catchment, largely attributable to historical and current agricultural practices (e.g. cattle accessing the creek).

Whilst all sites monitored in 2019 have maintained their average SIGNAL pollution class of Severe, all sites (excluding WO2), recorded their lowest ever SIGNAL score (**Figure 9**). These sites display a trend of reduced SIGNAL scores from 2017, correlating with below average rainfall (**Table 3**; ELA, 2018; ELA, 2019) with subsequent reduced stream flow (

Figure 2 **and**

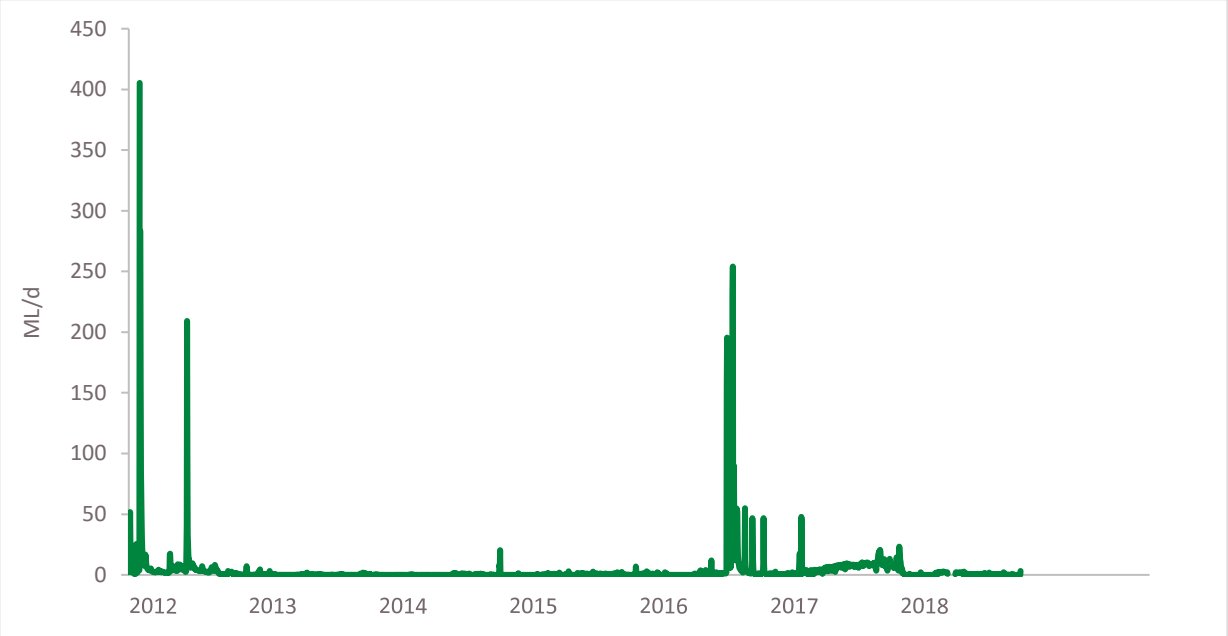

Figure 3) during the same period. As water levels decrease, macroinvertebrate habitat size and diversity is reduced. Combined with water quality parameters mostly outside of ANZECC guidelines during 2019 surveys (Error! Reference source not found.), these results demonstrate the impact of reduced water availability and quality on macroinvertebrate communities (Chessman et al. 1997).

As such, 2019 macroinvertebrate results indicate that climatic factors, along with past and ongoing agricultural practices, are the main factors influencing stream health in the catchments surrounding the WCM. SIGNAL scores display a peak during 2011 to 2013 which, as discussed above, is a result of SIGNAL scores being abundance weighted during these years (Landline Consulting, 2011; 2012; 2013).

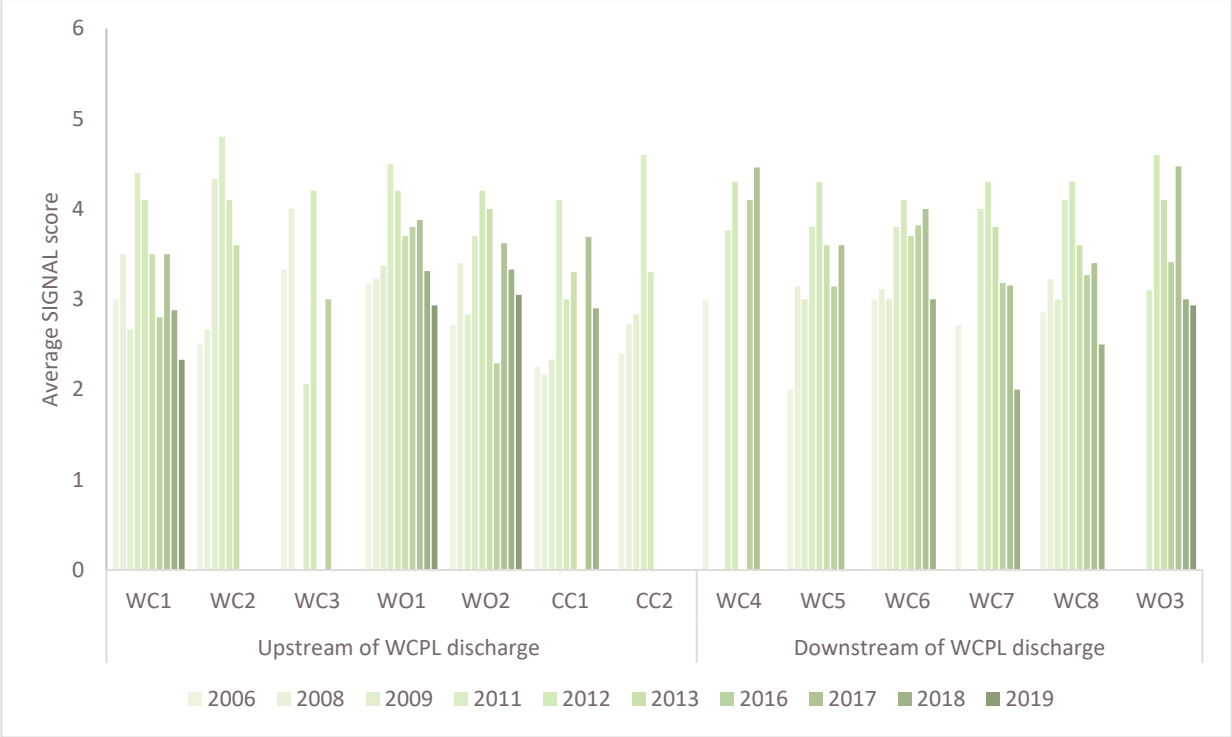

Figure 9: Average SIGNAL macroinvertebrate scores across all sites and years

5. Conclusions and recommendations

A total of thirteen (13) permanent sites along Wilpinjong, Wollar and Cumbo creeks underwent SHM in 2019. Only four (4) sites (WC1, WO1, WO2 and WO3) were able to be monitored for water quality and macroinvertebrates however, due to low water levels resulting from prolonged drought conditions and the cessation of water discharge from the WCPL licensed discharge point in November 2018.

The habitat condition at all 13 sites were classified as either good or very good, which places the sites in the mid-range of aquatic habitat scores, typical of catchments in the surrounding region. Overall, aquatic habitat results have remained largely consistent across survey years, with differences primarily relating to changes in stream bed macrophyte and groundcover, as a result of fluctuating water levels and climatic conditions.

Water quality results continue to be outside of ANZECC guidelines across most sites for both DO and EC. Results for both parameters are consistently outside of ANZECC guidelines and fluctuate considerably across years, stream flow levels and at sites both upstream and downstream of the WCPL licensed discharge point indicating that natural variables rather than mining operations are responsible for these results. Turbidity was high across all sites surveyed in 2019 reflective of the small and isolated nature of the pools from which the samples were taken.

Macroinvertebrate results recorded in 2019 were poor, with overall low taxa diversity and low SIGNAL scores, indicating severe pollution. Despite the low taxa diversity and SIGNAL scores recorded in 2019, they do not trigger further investigation under Section 5.3 of the WCPL Surface Water Management and Monitoring Plan (WCPL, 2017a). Compared to previous years, the 2019 results show a decrease in SIGNAL scores, which has been observed both upstream and downstream of the WCPL licensed discharge point. Climatic factors and flow regimes are a dominant influence on aquatic ecological communities, with the reduction in stream flow in Wilpinjong Creek since 2017, combined with below average rainfall resulting in lower SINGAL scores.

A revegetation program involving the planting of native riparian species has commenced within Wilpinjong Creek. The continued implementation of this program will assist in improving the health of the aquatic environment surrounding WCM. The addition of retention devices to the stream, such as logs or boulders, will increase the creeks capacity to retain coarse particulate organic matter, diversify aquatic habitat and reduce erosive power during high flow events.

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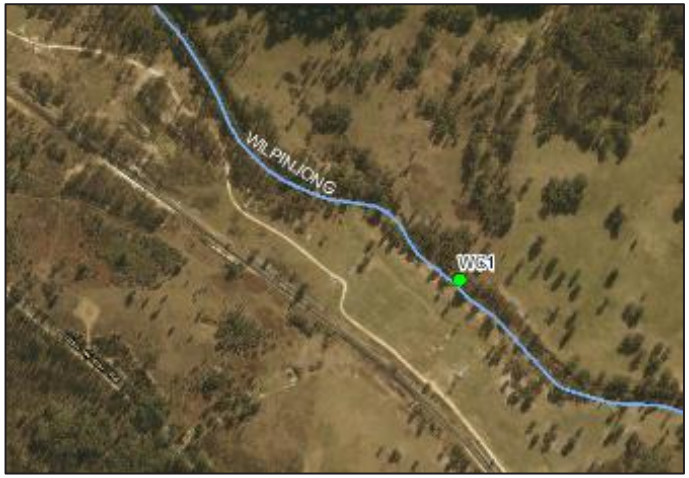
Wilpinjong Coal Pty Ltd. 2018. *Environmental Protection License (EPL) 12425 Monitoring Data Monthly Summary Report for 1 November 2018 to 31 November 2018*. Wilpinjong Coal Mine, Peabody Energy.

Appendix A Site Photos




Site WC1 (from left to right: site location, upstream, downstream (19/11/2019))


Site WC2 (from left to right: site location, upstream, downstream (19/11/2019))


Site WC3 (from left to right: site location, upstream, downstream (19/11/2019))


Site WC4 (from left to right: site location, upstream, downstream (19/11/2019))


Site WC5 (from left to right: site location, upstream, downstream (19/11/2019))


Site WC6 (from left to right: site location, upstream, downstream (19/11/2019))


Site WC7 (from left to right: site location, upstream, downstream (19/11/2019))


Site WC8 (from left to right: site location, upstream, downstream (19/11/2019))


Site WO1 (from left to right: site location, upstream, downstream (20/11/2019))


Site WO2 (from left to right: site location, upstream, downstream (20/11/2019))

Site WO3 (from left to right: site location, upstream, downstream (20/11/2019))

Site CC1 (from left to right: site location, upstream, downstream (19/11/2019))


Site CC2 (from left to right: site location, upstream, downstream (19/11/2019))

Appendix B Macroinvertebrate data

Order/Class	Family	Signal Score	WC1	WO1	WO2	WO3
Coleoptera	*Dytiscidae*	2	9	9	3	
	Hydraenidae	3	4		1	
	Hydrophilidae	2	2		1	2
	Hydrochidae	4		2		3
Crustacea	*Ostracoda*		40		13	3
	Cladocera		40	5		
	Copepoda		40			
Decapoda	*Atyidae*			4	1	2
Diptera	*Ceratopogonidae*	4		8	19	1
	Culicidae	1	8		1	4
	Dixidae	7			2	
	Chironomidae (chironominae)	3	12	23	30	14
	Chironomidae (orthocladiine)	4			3	
	Chironomidae (tanypodine)	4		21	3	14
	Dolichopodidae	3	1		1	
Ephemeroptera	*Baetidae*	5		2	5	
	Caenidae	4				2
Hemitptera	*Corixidae*	2	11	12	2	
	Micronectidae	2	7	5	11	15
	Notonectidae	1	8	7	8	1
	Veliidae	3	3	1	1	2

Order/Class	Family	Signal Score	WC1	WO1	WO2	WO3
Hygrophila	*Physidae*	1		3		2
Odonata	*Aeshnidae*	4	1	10	2	1
	Coenagrionidae	2	6	8	12	10
	Corduliidae	5		7	2	6
	Lestidae	1			4	
Oligochaeta			11			1
Ostracoda				37		
Platyhelminthes		2		1		
Trichoptera	*Hydroptillidae*	4				1

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Box Type	Amount	Install Height	Desirable Location									
			1	2	3	4	5	6	7	8	9	10
Double chamber microbat	10	3 to 5				2		1	1			
triple chamber microbat	10	3 to 5		2		2		1	1			
glider front	5	3 to 6		2	x	1		1	1			
glider back	5	3 to 6	x	1	x	2		1	1			
possum	10	4 to 8	x	3		2		1	1			
quoll	5	1 to 4			x	2		1	1			

Box Install ratio											
	Area of Location (ha)	1.4	1.3	1.3	4.5	1	0.8	0.96	1.6	1.9	1.7
	Required Boxes to be Installed										
10-20 per ha	(10 per ha)	14	13	13	45	10	8	9.6	16	19	17
	Boxes to be Installed	0	8	0	11	0	6	6	0	0	0

x	769,106.60	769,106.60	769,840.37	769,840.37	771,208.63	772,169.20	773,014.49
y	6,422,265.04	6,422,265.04	6,421,296.46	6,421,296.46	6,420,488.53	6,420,571.77	6,420,655.03